The Journal of Thoracic Surgery

VOL. 9 APRIL, 1940 No. 4

Original Communications

A SELECTIVE TYPE OF THORACOPLASTIC OPERATION

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THORACOPLASTIC operations, as applied in the treatment of pulmonary tuberculosis, are used to aid in securing rest for a diseased portion of the lung and to aid in the closure of cavities in those selected patients in whom other less radical measures have proved ineffectual.

As early as 1885, de Cerenville[1] realized the importance of breaking the continuity of the bony frame over pulmonary cavities. He resected 3.5 cm. each of the second and third ribs anteriorly, or "as many ribs as necessary, according to the extent of the cavity."

Brauer[2] was first to propose a surgical collapse comparable to that which can be obtained by a satisfactory pneumothorax. He suggested a very extensive procedure in which he proposed the complete resection of the second to ninth ribs, inclusive. The mortality from this procedure was high, but the ultimate benefit to the diseased lung of the survivors was gratifying.

Hedblom[3] emphasized the value of multiple stage operations as a means of reducing operative mortality. Lambert and Miller[4] argued that we should operate first at the site of the disease and directed attention toward the upper lung field as the most frequent site of pulmonary disease. At about the same time, consideration was being given to partial thoracoplasty as a means of obtaining satisfactory results. Partial thoracoplasty performed in multiple stages afforded a conservative means of removing long segments of ribs and still preserved a healthy lower lung.

Alexander,[5] independently, began the removal of longer lengths of ribs. O'Brien[6] pointed out that all of the uppermost ribs and part of the sternum could be resected through a posterolateral incision, and he recommended removal of the uppermost three ribs as far forward as their cartilages. Semb[7] contributed the extrafascial apicolysis, pointing the way toward a still more complete collapse of the apical portion of the lung. Wangensteen[8] and Head[9] have described a multiple short incision approach as a means of avoiding extensive injury to the heavy muscles of the shoulder girdle. It is obvious that the trend has been from the limited resections as first described, through the extensive removal of all ribs as

Read before the Twenty-second Annual Meeting of the American Association for Thoracic Surgery at Los Angeles, Calif., July 5, 6, and 7, 1939.

proposed by Brauer, to a middle ground where the resection is made as nearly complete as possible over the diseased portion of the lung field, avoiding extensive muscle damage. These contributions constitute some of the high lights in the development of an effectual limited thoracoplasty.

In 1933, we presented some of our early efforts toward the modification of the thoracoplasty.[10] At that time, we performed a first-stage thoracoplasty which consisted of an anterior operation, with removal of the uppermost two or more ribs, including their cartilages and the edge of the sternum. No particular effort was made to resect the ribs beyond the midaxillary line at this first stage. After removal of the ribs anteriorly, an extensive anterior mediastino-apicolysis was performed. Subsequent stages were carried out posteriorly in the orthodox manner, except that it was not necessary to extend the posterior incision to the top of the shoulder, thereby causing less injury to the heavy shoulder muscles.

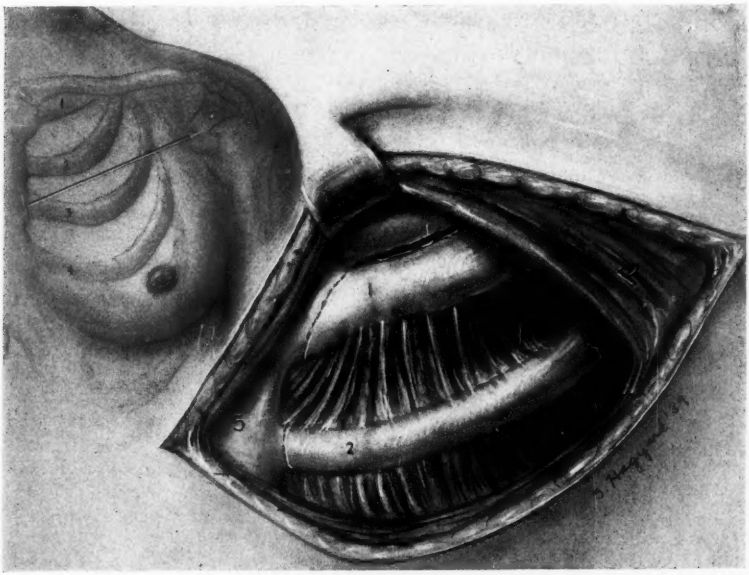

Fig. 1.—Insert shows line of incision extending medially and downward from a point below the clavicle near the head of the humerus to the sternum at the third sternochondral junction. The main diagram shows retraction of the upper border of the pectoralis muscle. The periosteum has been stripped from the first and second ribs. The intercostal bundles are intact.

Further experiences with this operation have led us to make certain refinements in the technique. We now perform an anterior operation at the first stage, an incision being made from a point just medial to the head of the humerus and below the outer end of the clavicle downward and medial to the junction of the third rib with the sternum. The skin, subcuticular tissues, and outer muscle fascia are sectioned. The pectoralis major muscle fibers are separated, except near the sternum; here the fibers below the incision are cut across parallel with the sternum. One or two vessels require ligation. Immediately the second and third ribs are fully exposed, except those portions that are obscured laterally by insertion of the pectoralis minor. The fibers of this muscle are freed as the periosteum is freed from the ribs. (Fig. 1.)

As a rule, the second rib is freed first of its perichondrium and periosteum on its anterior and lateral aspects; then the perichondrium is freed from the posterior surface of the cartilage. The cartilage is sectioned near its sternal junction; the rib is then rotated lateralward and downward or upward, as convenience requires, and further separation of the periosteum on the inner surface of the rib is carried out. We have found that the use of gauze as a blunt dissector in the separation of the periosteum from the inner surface of the ribs is a safe procedure. At the same time, it aids in compressing the underlying tissues that have been freed. When the desired length of rib has been freed of its periosteum, the rib is cut with a regular Stille rib shear. With the rib pulled lateralward, the rib shear approaches it from its inner surface. The first rib is now approached, the perichondrium and periosteum being incised along the anterior surface of the rib and stripped from the mid-outer surface toward the lower edge. Then the inner surface is freed of its perichondrium and periosteum, leaving the upper outer surface and upper edge of the rib to be dealt with last. Near the costosternoclavicular junction, the perichondrium is firmly attached, but once it is separated, the cartilage can be sectioned near the sternum safely. It is rarely necessary to ligate vessels during this procedure. The cartilage of the first rib having been sectioned, the first rib can be extended downward and lateralward to facilitate the freeing of the scalene attachments. The periosteum can now be stripped all the way to the transverse process of the first thoracic spine without difficulty. It is desirable to have available at least one retractor about 1½ inches wide and 6 or 8 inches deep, to be inserted between the soft tissues of the chest wall and the ribs as the ribs are freed of their muscular and periosteal attachments. (Fig. 2.)

Fig. 2.—The first and second cartilages have been sectioned near the sternum. The parietal and mediastinal pleura have been freed. The underlying lung is collapsed to form a cone still attached at the apex.

The next step consists in a careful removal of all costal cartilage stumps, together with a portion of the edge of the sternum. No ledge is allowed to remain for uncollapsed lung to creep behind. A careful mediastinolysis is now performed, extending the procedure up over the apex of the lung anteriorly and then lateralward and posteriorly to the body of the vertebrae. We formerly destroyed

all attachments of the lung to the apex, similar to the procedure described by Semb. But we found that at times, through a deviation in the direction of a bronchus, secretion was retained in a cavity and the patient became very sick, with a high temperature; or we found that, with the marked displacement downward, a cavity was displaced into the wider portions of the thoracic space, where a limited thoracoplasty would fail to bring about its closure. On the other hand, if it had been held up in the narrower portions of the thoracic space, closure could have been expected.

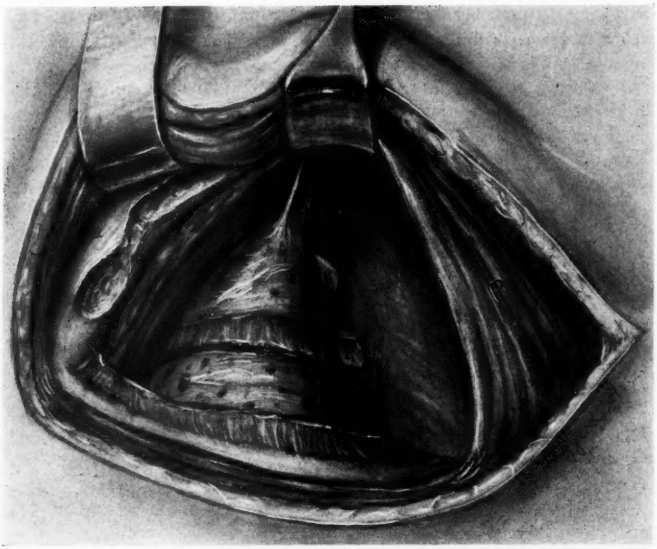

Fig. 3.—The first and second ribs are removed. The posterior stumps *1* and *2* are seen projecting from behind the cone of lung which is attached to the dome of the thoracic space by one small band. The chondral stumps, along with the edge of the sternum, have been resected.

We now prefer to leave a very narrow attachment between the lung and the uppermost portions of the thoracic wall near the midapical region (Fig. 3). By so doing, the collapsed lung assumes the shape of a narrow pyramid or cone, with its apex uppermost. This cone of lung can then be subjected to firm pressure by the scapula from behind and by pads placed in the axilla and below the clavicle. The use of these pressure pads is a very important adjunct in our attempt to close cavities, and they should be carefully placed high in the axilla and also just below the clavicle over the anterior chest wall from which the ribs have been removed. They should not be left off until the lapse of at least three months following the last stage of the thoracoplasty. Formalin, 10 per cent, is applied to the periosteal beds. Closure is in layers without drainage.

The second stage of the operation is performed through the posterior approach from two to three weeks later. At this operation, the incision extends from the lower border of the fourth rib between the scapula and spine, and downward and forward below the angle of the scapula to a point near the midaxillary line. The third and fourth ribs are then freed of their periosteum and sectioned at a measured distance from the spine. (Figs. 4 and 5.) The articulation between each rib and its transverse process is identified, and a flat periosteal stripper is used to

separate the rib from the transverse process at its outer articulation. The rib is then dislocated inward by pressing on its distal end. This frees the rib except at its articulation with the transverse process near the junction of the wing of the transverse process with the body of the spine. The rib is then rotated downward and outward to be extracted from this final attachment. No troublesome bleeding has been encountered during this process of disarticulation and extraction of the ribs, and we find it more satisfactory than trying to remove the rib stumps with a rongeur after the rib has been sectioned near the spine. Each rib is dealt with in this manner, except that the stump of the first rib is usually cut close to the first transverse process and no especial effort is made to remove its residue. The transverse processes of the second, third, and fourth spines are then removed with rongeurs. The attachments of all intercostal bundles are sectioned, leaving only the intercostal nerves and vessels intact. We now find that the structures along the vertebral gutter are entirely freed to the body of the vertebrae. They are easily shoved lateralward and forward to aid in obtaining a complete collapse.

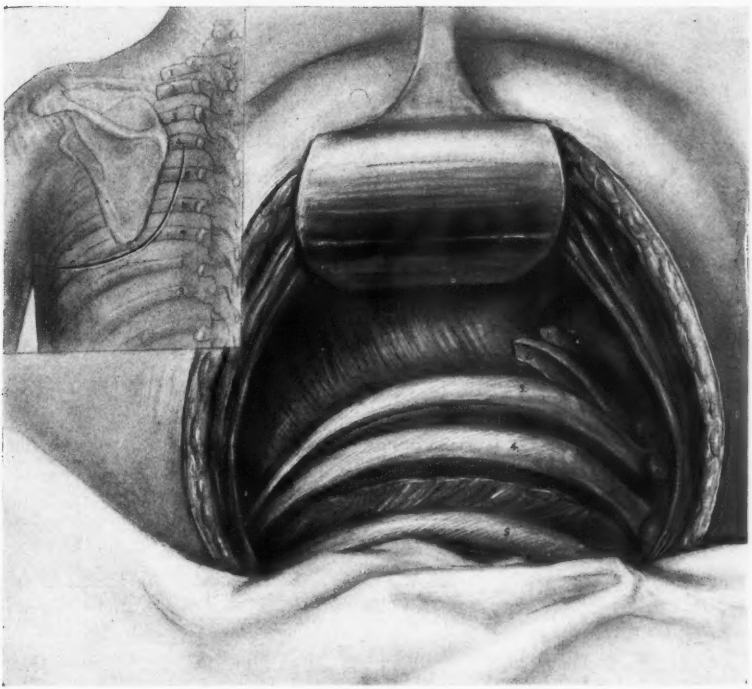

Fig. 4.—Insert shows line of incision extending from the level of the fourth rib between the posterior border of the scapula and spine downward and forward from there to a point near the midaxillary line. There is very little damage to the heavy muscles of the shoulder. The main drawing shows the exposure produced by this type of incision. Stumps of the first and second ribs, together with the third, fourth, and fifth ribs which have been denuded of their periosteum, are exhibited. Transverse processes of the second, third, and fourth thoracic spines are exposed.

Subsequent stages of the operation are performed at intervals of from two to three weeks as indicated, with 10 per cent formalin kept applied to the periosteal beds to delay bony regeneration. We have encountered only one or two instances in which the anterior chest wall failed to become fixed by perichondrial and

periosteal regeneration following the resection of the anterior ends of the costal cartilages and ribs. In these instances, there seemed to be as much deficiency in rib regeneration as in cartilaginous regeneration. We do not look upon this as a proper excuse for one to neglect the removal of the costal cartilages in his attempt to produce a complete collapse over and about a diseased portion of the

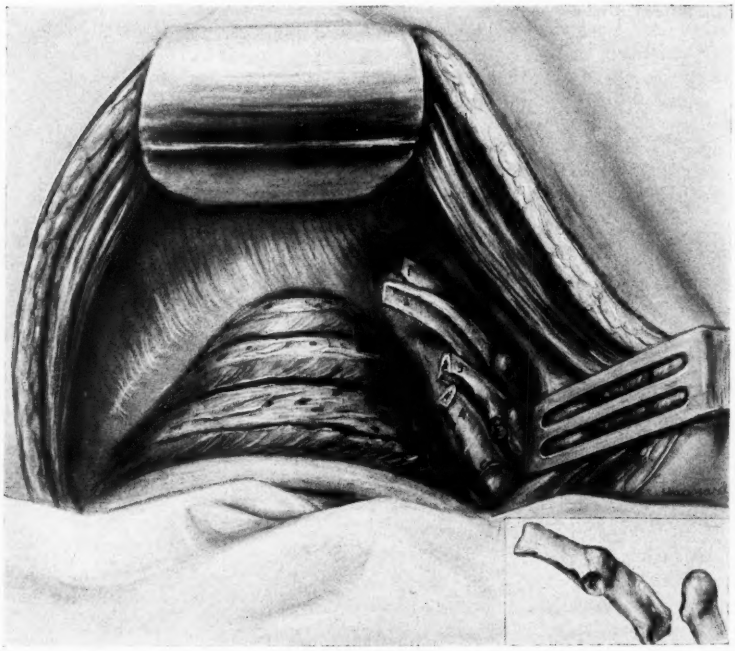

Fig. 5.—Segments of the third and fourth ribs are now removed. The underlying soft tissues have been freed along the spine and the posterior mediastinum. The articulation of the transverse processes with the corresponding ribs is noted. At *C* on the fourth rib, note the line of cleavage through which the approach is made to separate the rib and the transverse processes. The third rib and its transverse process have been freed, and the outermost facet, *F*, is exposed. In the insert the extracted stump and its transverse process are shown.

lung. Neither have we encountered cardiac embarrassment when the third and fourth cartilages were removed. The deformity that follows the anterior operation is not a legitimate excuse for failing to remove the anterior portions of the ribs and cartilages. As a matter of fact, if one has preserved the continuity of the muscles of the axillary folds, and if there is a moderate amount of subcuticular adipose tissue, the deformity is not noticeable. Although deformity may not be marked, the new-formed bone of the regenerated ribs forms a hard wall which lies very close to the mediastinum and which can be felt by driving the hand into the axilla or by palpating deeply along the edge of the sternum.

We find certain advantages in the procedure as now carried out:

1. By doing an anterior operation at the first stage, we obtain a maximum of collapse with a minimum of damage to the muscles and soft tissues.

2. When the first two or three ribs are resected by the anterior approach, one is able to obtain a very satisfactory exposure of the remaining stumps posteriorly without injury to the major muscles of the shoulder girdle.

3. The mediastino-apicolysis, leaving a minimal attachment of the apex to the chest wall, mobilizes the lung but does not permit the diseased apex to drop into the wide midthoracic space.

4. We can be assured of a complete freeing of all structures along the vertebral gutter by disarticulating the ribs from the transverse processes of the spine, extracting the ribs, and subsequently removing the transverse processes.

5. We are adhering to the sane principle of multiple stage operation.

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DISCUSSION

DR. JEROME R. HEAD, CHICAGO, ILL.—I think one important point that Dr. Hudson brought up which differs considerably from the accepted practice is that of leaving the apex of the lung attached to the dome of the thorax. I believe it has been the experience of most of us that, with Semb apicolysis, we have had to follow the cavities from the apex into the lower lung, and that, on this account, it has been necessary to perform much more complete thoracoplasties than would have been necessary had the apex of the lung remained attached to the dome of the thorax.

In 1936 I read a paper before this Society on the closure of large apical cavities by prethoracoplasty paraffin packs. At that time, I stated that the best results had been obtained in those cases in which the apex of the lung had been left suspended and the paraffin packed around it both on the lateral and the mediastinal surfaces. I still use this procedure and believe that it permits the closure of larger cavities than can otherwise be closed. It not only reduces the size of the cavities before thoracoplasty, but so stabilizes the mediastinum that any compression against it is adequate.

A STUDY OF THE IMMEDIATE AND LATE RESULTS IN 511 PATIENTS SUBJECTED TO THORACOPLASTY

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INTRODUCTION

DESPITE the intensive case finding programs in progress in many large centers, there is still in evidence that inevitable large number of patients with far-advanced tuberculosis for whom thoracoplasty offers the only hope of recovery. From the public health standpoint, as well as that of the individual, the management of this unfortunate group of patients presents a problem equally as important as the control of the lesser stages of this disease.

The modern type of extrapleural thoracoplasty, utilized in various clinics in recent years, has established itself as the one most valuable permanent collapse measure available to the thoracic surgeon. Although there are only minor differences in opinion among the various operators in regard to the technique of operation, there is still considerable disagreement in regard to the type of patient selected for operation.

The ultimate fate of the thoracoplasty patient undoubtedly depends in a large measure upon the type of operative risk selected. One can select only those who have an excellent or better than average chance for complete recovery, to the exclusion of a much larger group for whom the operation offers only a slight chance of recovery. Or, we can disregard the inevitable increase in fatalities and offer thoracoplasty to this latter group, with the hope that a sufficient number of patients will be salvaged to justify the use of the procedure.

Even though a larger number of fatalities will occur and a considerable number of patients will be physiologically handicapped if the latter course is chosen, it is our feeling that only the obviously desperate risk patient should be refused.

Only within the past three years have individual clinics completed a sufficient number of modern thoracoplasties to evaluate their results and to compare them with the results of the earlier operations. Although some of our patients have been operated upon too recently to allow a proper evaluation of the late results, we believe that a preliminary report on a comparatively large group of patients operated upon in our clinic will be of interest.

The results of the earlier types of thoracoplasty will be mentioned only briefly. In 1925, Alexander[1] reported the results in 1,159 collected patients, in approximately 36.8 per cent of whom closure of the cavity and disappearance of tubercle

Read before the Twenty-Second Annual Meeting of the American Association for Thoracic Surgery at Los Angeles, Calif., July 5, 6, and 7, 1939.

From the Department of Surgery, Wayne University School of Medicine, Herman Kiefer Hospital (Detroit Department of Health), and the American Legion Hospital, Battle Creek, Mich.

bacilli from the sputum occurred; 38.7 per cent of the patients died within a variable number of years after operation.

Hedblom and Van Hazel[2] reported the results in a series of 3,762 cases collected from the reports of a large number of clinics and operated upon between 1925 and 1934. Of this group, 35.4 per cent were able to work and were sputum-negative and practically symptom-free; 22.1 per cent were able to do some work, but had positive sputa and some symptoms; 5.5 per cent were unable to work, and they still shed tubercle bacilli; in 0.2 per cent, the results were not evident; 3.5 per cent were untraced; and 33 per cent were dead.

A number of operators have reported their results with the modern type of thoracoplasty within the past few years; only a few of these will be mentioned briefly here.

Freedlander and Wolpaw,[3] in 1937, reported a series of eighty-five patients who had undergone thoracoplasty, and compared the results with those of a control group of fifty-eight patients who refused thoracoplasty. The conclusions drawn from this excellent comparison study leave little doubt as to the value of thoracoplasty. The results in Freedlander's series, disregarding the control group, are as follows: able to work, 46 per cent; improved, 19 per cent; unimproved, 13 per cent; dead in eight weeks, 7 per cent; and dead in five years, 7 per cent.

Haight and Alexander[4] have reported the results in 119 patients with cavernous pulmonary tuberculosis, with or without empyema, from the latter part of 1932 to the end of 1934. Ninety-nine, or 83.1 per cent, of these patients have completely closed cavities and persistently negative sputum. From two and one-half months to two and one-half years after operation, only thirteen, or 10.9 per cent, of the 119 patients have died. (Two other deaths from causes unconnected with operation or tuberculosis were not included among the thirteen deaths.)

One hundred and six living patients have closed cavities and negative septum. One hundred and two, or 96.2 per cent, of the 106 living patients have closed cavities on the operated side, but three of them have positive sputum from open cavities in the lung of the unoperated side.

In June, 1934, Coryllos[5] reported the results in forty-three patients operated upon between January and November, 1933, as follows: cured, 72.1 per cent; improved, 18.6 per cent; unimproved, 4.6 per cent; dead, 4.6 per cent.

Overholt,[6] early in 1938, reported a series of 370 patients, with the following results: working, 39 per cent; condition apparently arrested, 19 per cent; quiescent, 9 per cent; improved, 14 per cent; no change, 6 per cent; dead 13 per cent. At the time of his report, 121 cases were considered completely rehabilitated. Two hundred and forty-eight of the 307 completed cases were expected to fall into the apparently arrested group and to be able to carry out varying degrees of activity.

In February, 1939, Dolley, Jones, and Paxton[7] reported the late results in a collected series of 1,386 cases, plus 250 cases of their own. The mean percentage of the entire collected series was 38 per cent able to work, 25 per cent improved, 15 per cent unimproved, 11 per cent dead in eight weeks, and 7 per cent dead in five years.

In Dolley, Jones, and Paxton's own series of 250 cases, 40 per cent were able to work; 14 per cent were improved; 7 per cent, unimproved; 10 per cent, dead in eight weeks; and 9 per cent, dead in five years.

The first 63 cases in this series were reported by O'Brien[8] in 1933. Among these patients there was only one operative death, an operative mortality of 1.58 per cent; fifty-five of fifty-six patients operated upon in Herman Kiefer Hospital had positive sputum before operation, and forty-six, or 83 per cent, had negative sputum at the time of the report. Cavity closure occurred in 92.7 per cent of the fifty-five patients.

SELECTION OF PATIENTS

So many factors are involved in the selection of patients for thoracoplasty that each person must be considered as an individual problem. It may be stated, as a general rule, that any patient whose general condition is reasonably good, who has not recently presented symptoms of toxemia, whose cardiac and respiratory reserves are considered adequate, and in whom the lesser collapse measures have failed within a reasonable trial period, should be considered a suitable candidate for operation. Patients with exudative and mixed lesions and with rather extensive disease in the contralateral lung, if it can be controlled by contralateral pneumothorax, are not rejected.

Until very recently, there have not been available sufficiently accurate measures of the ability of the patient to withstand operation, especially from the standpoint of the infringement upon his functional pulmonary reserve. The excellent work on bronchospirometry reported by the late Dr. Hans Jacobeus[9] has opened up an entirely new approach which should prove an invaluable aid. Gebauer[10] has recently devised a flexible double bronchoscope which will soon be available at a reasonable cost, making possible the wider application of Jacobeus' observations on the individual functional capacities of each lung.

Whitehead's[11] work on oxygen saturation of the blood has been used in several recent cases of thoracoplasties, and we feel that it will give us considerable information in regard to the patient's ability to withstand operations.

Aside from clinical observations on the degree of dyspnea, acceleration of pulse, etc., produced by varying degrees of exercise, vital capacity determinations have been the only measure of the patients' respiratory reserve. In our experience, vital capacity has been of little value and often has been misleading. By far the greater number of patients in this series had vital capacities of less than 1,750 c.c. Our arbitrary lower limit of vital capacity of 1,000 c.c. has been disregarded occasionally, nearly always with disastrous results. These patients, although in some instances withstanding the immediate operative procedure, usually die within a few weeks or months from failure of the right heart.

For the past three years, we have felt it necessary to investigate the tracheobronchial tree before subjecting a patient to thoracoplasty. Occasional bronchial stenosis or complete atresias are encountered. which either contraindicate thoracoplasty or require dilatation during the course of thoracoplasty.

More frequently ulcerative lesions are discovered which, in our opinion, necessitate a period of treatment before proceeding with thoracoplasty.

RESULTS

During the period from August, 1932, to Dec. 31, 1938, a total of 1,404 operations were performed upon 511 patients.

In 202 patients, the disease was unilateral, and in 309 patients, there was disease in the contralateral lung. Ninety-seven patients had contralateral pneumothorax at the time of thoracoplasty.

In 368 patients, the disease was predominantly productive; in 104, it was mixed; and in 39, exudative.

Four hundred and ninety-six patients of 511 had cavernous lesions. In fourteen patients, thoracoplasty was done primarily for closure of tuberculous empyemas, and in three other empyema patients, cavity was present.

There were nine diabetic patients in the series, seven of whom were classified as from moderately severe to severe cases, and two were considered mild.

There were nine patients with syphilis, two of whom were of the congenital type.

Forty-five patients had tracheobronchial disease of some nature before, during, or after thoracoplasty.

TABLE I

IMMEDIATE AND LATE DEATHS IN 511 PATIENTS OPERATED UPON FROM AUGUST, 1932, TO JAN. 1, 1939

RACE	NUMBER OF CASES	IMMEDIATE DEATH	LATE DEATH	TOTAL DEATHS
White	448	42	44*	86
Black	63	6	6	12
Total	511	48	50	98
Percentage		9.39	9.78	19.17

*Deaths due to accident and suicide not included.

With very few exceptions, the type of operation employed for the first stage was that described by O'Brien in an earlier report on some of these cases, i.e., the complete removal subperiosteally of the upper three ribs with their transverse processes through a posterior incision. Successive stages were performed, usually at three-week intervals, long sections of two or three ribs being removed at a stage until the desired amount of collapse was obtained. Anterolateral stages were done in forty-nine cases, and secondary operations (revisions) were necessary in seventy-one cases.

We realize that there can be no sharp dividing line between so-called operative deaths and late deaths based upon an arbitrary time limit. However, in our analysis of the deaths, it so happens that all which were considered definitely attributable to operation occurred within eight weeks. These were designated as immediate deaths, while those which occurred later were designated late deaths.

TABLE II

POSTOPERATIVE DAY ON WHICH DEATH OCCURRED IN FORTY-EIGHT DEATHS ATTRIBUTABLE TO OPERATION

P.O. Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14
No. Patients	1	4	5	5	4	4	1	2	1	0	3	1	1	4

Total deaths in first two weeks, 36

P.O. Week	3rd wk.	4th wk.	5th wk.	6th wk.	7th wk.	8th wk.
No. Patients	8	1	1	0	0	2

Total deaths in next six weeks, 12

Out of 511 patients in this series, forty-eight died within eight weeks of operation, and these were considered definitely operative deaths. During the period from two months to six and one-half years after operation, an additional fifty patients have died. Three additional deaths due to accident and suicide occurred in patients who had closed cavities and negative sputum and were clinically well. Inasmuch as these deaths were in no way attributable to the operation or to tuberculosis, we have not included them in the late fatality rate.

The total fatality rate is 19.17 per cent, the immediate being 9.39 per cent, and the late, 9.78 per cent. It is significant that, in sixty-three negro patients, the fatality rate is practically the same as in the remainder of the group.

TABLE III

ANALYSIS OF IMMEDIATE DEATHS BY STAGES

OPERATIVE STAGES	NUMBER OF OPERATIONS	NUMBER OF DEATHS	FATALITY RATE
First	512*	14	2.73
Second	455	25	5.49
Third	297	4	1.34
Fourth	104	5	4.80
Fifth	29	0	0
Sixth	6	0	0
Seventh	1	0	0
Total	1,404	48	3.42

*Five hundred and twelve first stage operations were performed upon 511 patients (one bilateral thoracoplasty included).

A further analysis of deaths following each operative stage, as seen in Table III, shows that the mortality is quite perceptibly higher following the second stage. Our experience has been that the extensive costal resection employed in the first stage operation has not been accompanied by the disastrous results which have been feared by some thoracic surgeons.

The high mortality following the second stage has been attributable, in a large part, to paradoxical respirations (with or without bronchial occlusion), and to consequent atelectasis and anoxemia. During the past three years, this has been markedly reduced by the removal of

fewer ribs (usually not more than sections of two ribs), and the routine use of bronchoscopic aspiration when retention of sputum and bronchial occlusion are suspected. There can be no doubt that, in a considerable number of cases, this expedient has been a lifesaving measure.

Only infrequently has it been necessary to subject the patient to more than four stages. The fifth and sixth stages represent secondary operations or revisions in practically every instance. The patient requiring seven stages had a very large cavity which stubbornly resisted closure. At the present writing, closure has been effected, sputum has been scanty and negative for more than two years, and the patient is clinically well.

TABLE IV

ANALYSIS OF DEATHS BY DECADES IN 511 PATIENTS FROM AUGUST, 1932, TO JANUARY, 1939

AGE GROUPS IN DECADES	TOTAL		IMMEDIATE DEATHS		LATE DEATHS	
	WHITE	COLORED	WHITE	COLORED	WHITE	COLORED
0- 9	0	1	0	0	0	0
10-19	20	5	2	0	4	1
20-29	186	30	13	3	14	1
30-39	148	22	14	1	18	4
40-49	73	5	12	2	5	1
50-59	20	0	0	0	5	0
60-69	0	0	0	0	0	0
70-79	1	0	1	0	0	0
Total	448	63	42	6	46*	7

*Includes three patients dying by suicide and accident.

Our experience with thoracoplasty in the very young has been disappointing. The youngest patient, and the only one in the first decade, was 8 years of age. Even though this patient is still living, and although cavity closure has been effected as nearly as can be determined by serial roentgenograms and tuberculous toxemia has been eliminated, the sputum is occasionally positive. There is marked scoliosis as a result of the resection of the transverse processes necessary to effect closure of the lesion.

Although gratifying results have been obtained in the adolescent group as far as cavity closure and sputum conversion are concerned, because of the possibility of marked deformity, we have been somewhat reluctant to subject these patients to thoracoplasty when it is at all possible that the lesion can be controlled by some other operative measure, even though thoracoplasty may become a necessity at some later date. It is becoming increasingly evident that extrapleural pneumothorax may prove to be a valuable procedure in controlling, at least temporarily, the lesions in this group of patients.

The largest groups of patients fall within the third and fourth decades, which comprise the period in which the disease most often

becomes clinically evident, and fortunately is the optimum age group as far as operative risk is concerned. Further analysis will show that the best operative risks are to be found in the third decade, whereas the operative risk becomes increasingly greater in late middle age and old age because of impaired cardiorespiratory reserve and impaired general resiliency.

TABLE V

TYPE OF DISEASE (THORACOPLASTY SIDE) AND IMMEDIATE MORTALITY IN 511 PATIENTS

TYPE OF LESION	NUMBER OF PATIENTS	UNILATERAL	BILATERAL	NUMBER OF IMMEDIATE DEATHS	PERCENTAGE OF FATALITY
Productive	363	150	218	35	9.5
Mixed	104	38	66	8	7.7
Exudative	39	14	25	5	12.8

Of the bilateral group, ninety-seven patients had contralateral pneumothorax at the time of thoracoplasty. There were nine immediate deaths in this group (operative fatality, 9.27 per cent).

In analyzing the deaths by type of disease, we were surprised to find that the percentage of fatality was only approximately 3 per cent greater in the exudative than in the productive type of lesion. The percentage of fatality in the mixed group was found to be even less than that in the productive. Even though the figure for the exudative lesions may not be considered a significant one from a statistical standpoint, it does indicate that a far greater number of these patients can be operated upon safely than was hitherto considered feasible.

As a general rule, we have proceeded with much more caution in these latter cases because of the greater dangers anticipated from excessive paradoxical respiration, autotuberculinization, and bronchiogenic spread.

In 1938 there was reported, from our clinic, a series of eighty-five thoracoplasties in the presence of contralateral pneumothorax.[12] Since that time, twelve additional patients with contralateral pneumothorax have been operated upon, making a total of ninety-seven. In this group, there were nine immediate deaths, or an operative fatality of 9.27 per cent, which is slightly below the figure for the group as a whole.

It is evident, from an analysis of the immediate deaths that, exclusive of the inevitable small group dying as a result of embolism, those dying from unavoidable complications incident to the tuberculous disease per se, and another small group in whom extrathoracic complications were the primary cause, the majority of deaths were directly attributable to purely mechanical disturbances in the cardiorespiratory mechanism.

TABLE VI

ANALYSIS OF IMMEDIATE DEATHS

PRIMARY CAUSES OF DEATH	NUMBER OF DEATHS
I. Disturbances of the cardiorespiratory mechanism	
1. Bronchial obstruction and paradoxical respiration	10
2. Inadequate pulmonary reserve	7
3. Inadequate pulmonary reserve and bronchial obstruction	4
4. Primary myocardial deaths	4
5. Deaths due to embolism	
Pulmonary	1
Cerebral	1
Air embolus	1
Fatal reaction from blood transfusion	1
6. Spontaneous pneumothorax	1
II. Tuberculosis and pyogenic infections	
1. Bronchiogenic spread	3
2. Autotuberculinization	3
3. Acute tuberculous pleurisy, with effusion in contralateral pneumothorax space	1
4. Pneumonia	2
5. Bronchopleurocutaneous fistula with empyema	2
6. Acute parotitis	1
7. Meningitis (tuberculous)	1
8. Wound infection	0
III. Extrathoracic complications	
1. Amyloid disease	2
2. Nephritis	1
3. Diabetic coma	1
IV. Operative shock	1
Total	48

There can be no doubt that varying degrees of paradoxical respiration ensue following the decostalization of a hemithorax. Whether or not paradoxical respiration will give rise to fatal anoxia depends upon the extent of decostalization and the coexistence of bronchial occlusion from retained secretions either on the thoracoplasty side or on the so-called good side, or both.

Paradoxical respiration in itself, even that incident to the decostalization of relatively large areas, as in the extensive first stage operation described in this paper, is very well tolerated by the great majority of patients when a complicating bronchial occlusion is not present. When the latter complication does present, bronchoscopic aspiration has proved an invaluable measure. The deaths as a result of this complication occurred in the earlier part of this series, during which time bronchoscopic aspiration was not a routine part of our postoperative treatment.

Only one death was attributable to operative shock. This occurred following an extensive Schede thoracoplasty.

Electrocardiographic studies were included in the routine preoperative study in the earlier cases in this series. However, it was

our opinion that little valuable information was contributed over and above our clinical evaluation, and consequently they were discontinued.

TABLE VII

CAVITY STATUS FOLLOWING OPERATION

NO. OF PATIENTS WITH CAVITY BEFORE OPERATION	CAVITY CLOSED AFTER OPERATION	CAVITY OPEN AFTER OPERATION
447*	389 (87.02%)	58 (12.98%)

*After the elimination of forty-eight immediate dead and sixteen patients (including thirteen with empyema) who had no cavity before operation.

TABLE VIII

SPUTUM STATUS FOLLOWING OPERATION

NO. OF PATIENTS WITH POSITIVE SPUTUM BEFORE OPERATION	SPUTUM NEGATIVE AFTER OPERATION	SPUTUM POSITIVE AFTER OPERATION
447*	365 (81.65%)	82 (18.35%)

*After the elimination of forty-eight immediate dead and sixteen patients with negative sputum (including thirteen patients with empyema and no cavity).

After eliminating forty-eight patients who died immediately, there were 447 patients who had open cavities. In 389, or 87.02 per cent, of these patients, cavity closure was effected by thoracoplasty. In 365, or 81.65 per cent, of 447 patients who had positive sputum before operation, sputum conversion occurred subsequent to operation.

In twenty-four patients in whom a cavity was not demonstrable by roentgenograms following thoracoplasty, the sputum remained positive. The source of positive sputum in six of these patients was definitely due to tracheobronchial tuberculosis. The sources in the re-

TABLE IX

ANALYSIS OF LATE DEATHS*

I. Deaths due to tuberculosis:	
1. Bronchiogenic spread and reactivation	17
2. Pulmonary hemorrhage	4
3. Tracheobronchial tuberculosis	1
4. Tuberculous enteritis	5
5. Inadequate pulmonary reserve	10
6. Bronchopleural fistula with empyema (contralateral lung)	1
7. Bronchopleural cutaneous fistula and amyloid disease	1
II. Deaths due to nontuberculous disease:	
1. Cardiorenal disease	4
2. Amyloid disease	3
3. Syphilis	1
4. Diabetes	1
5. Pneumonia and toxemia of pregnancy	1
6. Pneumonia	1
III. Accidental deaths	
1. Suicide and automobile accidents	3
Total	53

*The late deaths include 27 patients upon whom thoracoplasty could not be completed. The cavities remained open.

mainder are about evenly distributed between uncontrolled disease in the contralateral lung and suspected incompletely closed cavities on the operated side.

In an analysis of the late deaths, as shown in Table IX, it is quite evident that the majority of the deaths occurred as a result of the progression of uncontrolled tuberculous disease. Inasmuch as the late deaths include twenty-seven patients upon whom thoracoplasty could not be completed for one reason or another, it is only logical to assume that bronchiogenic spread, pulmonary hemorrhage, and enteritis would figure prominently as causes of death.

In ten cases, the primary cause of death was considered to be inadequate pulmonary reserve. In several instances, the patients were sputum-negative and their cavities were closed, but because of extensive pulmonary fibrosis, death ultimately occurred as the result of failure of the right heart.

Eleven patients died as a result of nontuberculous disease.

TABLE X

PRESENT STATUS OF PATIENTS OPERATED UPON FROM AUGUST, 1932, TO JANUARY, 1939 (EXCLUDING THE IMMEDIATE DEAD)

STATUS	NUMBER OF PATIENTS	PERCENTAGE
In hospital	88	19.00
Home	296	63.93
Late dead	53*	11.45
Untraced	26	5.62
Total	463	100.00

*Includes three deaths by accident and suicide.

TABLE XI

STATUS OF TUBERCULOSIS IN 410 PATIENTS

STATUS	NUMBER OF PATIENTS	PERCENTAGE
Apparently cured	187	45.60
Arrested	82	20.00
Apparently arrested	40	9.75
Quiescent	26	6.35
Unstable	49	11.95
Untraced	26	6.35
Total	410	100.00

Of the 410 living patients, eighty-eight are still in the hospital, 296 are at home, and twenty-six are untraced. The status of tuberculosis in these patients is designated in Table XI. It will be noted that 335, or 81.7 per cent, are apparently cured, arrested, apparently arrested, or quiescent. Only twenty-six, or 6.35 per cent, are in the latter group. Forty-nine, or 11.95 per cent, are unstable.

In the apparently cured group, we have not been able to meet the strict requirements of the National Tuberculosis Association in regard

to negative sputum culture. However, all of these patients have persistently negative sputum concentrates, and a number are negative to culture.

Approximately two-thirds of the eighty-eight patients who are in the hospital have undergone recently completed thoracoplasties and have not fulfilled our required convalescent period of strict bed rest followed by graduated exercise. The remainder of the hospital group includes a number of incomplete cases, a few of whom may be completed ultimately, a small number of whom are incapacitated by extrapulmonary tuberculosis, and two, who, despite their being adequately controlled as far as pulmonary lesions are concerned, have been incapacitated by definite organic psychoses which necessitate institutional care.

TABLE XII

ECONOMIC STATUS

Number of patients working	186
Number of patients able to work but unemployed	38
Number of patients unable to work	160
Number of patients untraced	26
Total number of living patients	410

Of the 410 living patients, 225 are considered able to pursue some gainful occupation. However, due to the present economic situation, at least thirty-eight of this group have not been able to find steady employment. Inasmuch as a large number of these patients are unprepared for anything except unskilled labor, it is not surprising that this condition exists, especially in view of the fact that the large manufacturing concerns are somewhat reluctant to rehire these men and women, once it is known that they have had tuberculosis. Most of the men are doing light work, full or part time, as salesmen, clerks, office workers, or filling station attendants, or in such occupations as factory labor (light work) or light work on W.P.A. projects, etc. Of the three who are doing heavy work full time, one is a truck driver, and the other two are working in the assembly line of a large automobile plant.

A large proportion of the women have returned to their duties as housewives, carrying on their normal activities. Six have successfully undergone one or more pregnancies, one woman having gone through four pregnancies since thoracoplasty without difficulty. A number of the younger women are clerical workers, stenographers, secretaries, telephone operators, saleswomen, dressmakers, and garment workers. A few are students in business and secretarial schools.

Even though it is inevitable that an occasional patient will not be able to stand the strain incident to his return to normal activity, it has been gratifying to see that the great majority of them have shown

a remarkable degree of stability. Of the 160 patients who are classified as unable to work, fifty-nine were operated upon in 1938. As a general rule, these patients are not allowed to work within a two-year period following operation. This automatically eliminates, from the able to work group, not only those operated upon in 1938, but also about 50 per cent of those operated upon during 1937. The remainder includes those previously classified as the unstable, and those who will require further operation or who have suffered reactivation of their disease.

DISCUSSION

Although we are far from satisfied with the total fatality rate in our series, we note that it compares very favorably with the mean of other recently reported groups, even though we are of the opinion that we have included a larger number of desperate risk patients than are usually selected for operation by most surgeons.

During 1937 and 1938, our immediate operative fatality rate has been 3.84 per cent and 5.08 per cent, respectively, which is well below the figure for the entire group. There is every reason to believe that this approximate mean should be maintained or lowered slightly. However, in the case of the late deaths, it is our impression that a figure comparable to, or even higher than, the one in the present series may be anticipated.

The percentage of revisions in the series has been, perhaps, somewhat greater than we should like. The inclusion of a considerable number of mixed and exudative lesions, in which further cavity formation has occurred following primary thoracoplasty, may account for a number of these. It may, in a small part, be attributable to the fact that we have resorted to apicolysis in only a very small percentage of cases. Even though lung mobilization has been resorted to more frequently in the more recent cases, we are somewhat reluctant to admit its efficacy except in carefully selected lesions. In regard to this problem, we are essentially in accord with the views of Dolley and his associates.[7]

We should like to stress again the importance of bronchoscopy as a routine diagnostic procedure before thoracoplasty, as well as an adjunct to the postoperative management of the thoracoplasty patient.

We have been impressed by the remarkable stability of the great majority of patients whose conditions were arrested or apparently arrested on discharge from the hospital and who have survived for at least a two-year period following operation. These patients are, for the most part, now working and carrying on under conditions of ordinary life. The incidence of "breakdown" and reactivation has been extremely low.

At a time when increasing enthusiasm is being shown for extrapleural pneumothorax, an operation which has been championed by some as a substitute for, or even a probable successor to, the modern thoracoplasty, we feel that it is particularly opportune to lend our support to the already firm conviction held by most thoracic surgeons that thoracoplasty has proved its value, and that it will continue to occupy its present position as the foremost permanent collapse measure.

SUMMARY

Five hundred and eleven patients who have been subjected to 1,404 stages of thoracoplasty have been reported.

The immediate fatality rate was 9.39 per cent; the late fatality rate, 9.78 per cent; and the total, 19.17 per cent.

Cavity closure was effected in 87.02 per cent, and sputum conversion in 81.65 per cent.

One hundred and eighty-seven patients are apparently cured; eighty-two, arrested; forty, apparently arrested; twenty-six, quiescent; forty-nine, unstable; and twenty-six, untraced.

Of 296 patients at home, 224 are working or are able to work.

An analysis of the deaths is presented.

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DISCUSSION

DR. SIDNEY SHIPMAN, San Francisco, Calif.—I would like to ask Dr. O'Brien what he means by a negative sputum in these cases. Does he mean gastric lavage?

DR. GEORGE ORNSTEIN, New York, N. Y.—Dr. O'Brien's paper was very interesting. The late Dr. Coryllos had made a similar study and had come to similar conclusions. In my mind, the results obtained by Dr. O'Brien should be compared to the untreated similar type of tuberculosis pulmonary disease reported by Barnes and Barnes, in which over 80 per cent were dead one year after admission to the sanatorium. With such a comparison, we can appreciate the importance of collapse therapy.

A method for measuring the result of collapse therapy has been discussed. Can it be based wholly upon obtaining a sputum free from tubercle bacilli? At Sea View we depend upon negative sputum for our yardstick of results. We go no further than the concentration test, for we have learned that, if one is persistent by culture and guinea pig inoculation, very few previously converted positive sputa will stand the test of remaining constantly negative. The constant negative sputum for tubercle bacilli by concentrated methods is a sufficient test. In ten per cent of these negative cases, disease will become reactivated.

DR. RICHARD H. MEADE, JR., Philadelphia, Pa.—I feel that something more should be said about Dr. O'Brien's presentation. Probably most of us doing this work feel that the lack of discussion is due to a unanimity of opinion. One particular feature about which I would like to ask for further discussion is in regard to the routine use of the bronchoscope. During the past year the great value of bronchoscopy has been very forcefully drawn to my attention, especially after thoracoplasty in patients with large cavities who have a lot of sputum and great difficulty in bringing it up. I am sure that the bronchoscope has saved several of my patients this year, and, undoubtedly, in the past some patients have died because they were not bronchoscoped. I am wondering whether the routine procedure is really wise and if it should not be limited to special indications. If the patient is able to expectorate satisfactorily, I cannot understand why it should be necessary to subject him to bronchoscopic aspiration. I should also like to ask if any members have had complications due to this bronchoscopic procedure. The death of one of my patients this year was due to a contralateral staphylococcus empyema which, in itself, would hardly have killed him, but which, in the presence of his low respiratory reserve, was enough to do so. Bronchoscopic aspiration had been carried out on two occasions prior to the appearance of the empyema. I cannot see that one can blame the bronchoscopic treatment directly, but I wonder if it might not have had some possible connection.

I would again like to congratulate Dr. O'Brien on the way he has presented this subject and the fact that he has emphasized the importance of getting away from the idea that we must have low mortality. I think that, when one is concerned with reporting very low figures, he is apt to deny operations to patients who should have them.

DR. ROBERT M. JANES, Toronto, Canada.—I have had the privilege of using a planograph in diagnosis for the past three years at the sanatorium where I work, and recently a much more modern and more up-to-date equipment at the General Hospital. The matter of expense of installation is always important. There is an apparatus at the Hamilton Sanatorium, where my brother works, that we have copied. I think the total expense of the equipment that we have was about $50.00. It is attached to an ordinary table.

If one has a good Bucky outfit, a reasonably satisfactory equipment for chest work can be installed for a very small amount of money. My personal feeling is that it is the greatest recent advance in x-ray diagnosis of pulmonary disease.

DR. LEO ELOESSER, San Francisco, Calif.—I would like to ask Dr. O'Brien what he does with blocked cavities. Our main trouble has been with large blocked cavities, which thoracoplasty displaces downward, but does not close. I would like to ask Dr. O'Brien if he loosens the apex with these cavities, and also what effect thoracoplasty has upon the cavity.

DR. E. S. BENNETT, Olive View, Calif.—Needless to say I enjoyed Dr. O'Brien's paper very much. We also enjoyed having him out here last year when he came to Olive View to spend a day or two with us. He happened to arrive at a time when we were discussing postoperative cases at a staff conference.

I do not think we should evaluate the results of thoracoplasty on the basis of the statistics of deaths alone. I cannot help but feel that a semisurgical invalid is just as much a problem as a complete medical patient who must be isolated for public health reasons and given adequate humane care. Also, I feel that our newer x-ray technique is showing that a great many operations that were previously considered successful are not so as regards complete cavity closure. It makes little difference if a patient's sputum before operation had twenty million organisms and after operation only one million expelled in the course of twenty-four hours, for it is still positive. This question of sputum conversion is something in which we are tremendously interested. I realize we must keep our feet on the ground on the subject, because we can become much too academic. However, a sputum should be negative to modern concentration methods for routine purposes, and then one should resort to a gastric lavage for acid-fast search if the patient is going to a home where there are children. We have to be careful here in Los Angeles in sending patients home, for we must obtain the permission of the health authorities. If we say that the sputum is positive by any method, it is hard to get that patient home. I think we should have a sound basis before we use the term "sputum conversion."

Personally, occupying the position I do, I feel very definitely that we must select cases for thoracic surgery. Certainly, in the average thoracic case, the vital capacity must be taken into consideration. Often, there is not the reserve to carry through the operation. We cannot give everybody a chance to have thoracic surgery. That is impossible. We must be practical. Our problem is the treatment of the individual and the community control of tuberculosis. In an organization such as ours we are cognizant of two or three factors. We feel that we must make the most satisfactory use of our available beds, facilities, and finances. I do not know whether the rest of you are worried about the financial side, but I know that we are—we have to be. It seems to me, in a cold-blooded way, that a certain amount of choosing and selection must be based upon who should be given the greatest chance, estimating in advance as best we can the ultimate result. I am sitting behind a wave of two thousand cases, and I am pretty conscious of the fact that we have to pick and choose. Frankly, I do not agree that everybody should be given a chance to receive thoracic surgery, for I think that certain people are more entitled to the chance than others. I do not believe we can take the patients as they come and do the job satisfactorily, either in the best interest of the patient or in the interest of community control of tuberculosis.

DR. W. L. ROGERS, San Francisco, Calif.—I should like to bring out two points that we have found of particular interest. First, in regard to respiratory reserve, Dr. O'Brien has mentioned the vital capacity. I believe this may prove a most unreliable test as generally applied, certainly in choosing our cases in respect to their respiratory reserve. For example, a patient 55 or 60 years of age whom you feel may deserve serious consideration for thoracoplasty may have a

vital capacity of as much as 2,600 or more, but obviously, in this particular case, let us say, his vital capacity may not be a true criterion of the respiratory reserve because of existing fibrosis, emphysema, etc. Therefore, he may ill afford the loss of any lung tissue whatever. On the other hand, a woman in her early twenties had a vital capacity of 750, with no apparent dyspnea. This brought to our attention the possibility that perhaps, in her case also, the vital capacity would not prove a reliable criterion. A little over a year ago I started taking the vital capacity of each lung by blocking off the diseased lung through the bronchoscope. This was a rather simple method, and not only did we obtain the vital capacity of the good lung, but we were also able to time the respiratory rates over a period of from ten to fifteen minutes with the diseased lung completely blocked off. As a result, in a few cases we have been able to operate on those having a so-called vital capacity of less than 1,000 c.c., because we found that, after blocking off the diseased lung, very little difference was observed in the respiratory rate, and the vital capacity was lowered by only 100 to 150 c.c. I believe that, if we carry on this particular study in those cases which we consider borderline risks or in those we may consider candidates for pneumonectomy, it may prove of value.

The second point that I would like to stress is that we have found it very efficacious in borderline cases or where bronchial obstruction or bronchial disease may be suspected to bronchoscope the patient before operation. I do not recall any case that has been upset following the first stage due to omission in bronchoscopy. However, I believe it is the second or third stage in which existing bronchial disease may play an important role. Therefore, if there is any question of existing bronchial disease, bronchoscopy should be seriously considered before attempting a second stage. Occasionally we have been surprised to find the continued positive sputum coming from the so-called good lung.

Our clinic under Doctor Eloesser's supervision has been noted for its conservative operative procedures. I do not believe we have carried this out with the thought of keeping mortality down. One must consider the fact that a certain group of these people upon whom we have operated very extensively are still totally disabled; while their sputum may be negative, from an economic viewpoint they are still a total liability to the community.

DR. EMILE HOLMAN, San Francisco, Calif.—I should also like to report the experience we have had in our clinic with patients having a vital capacity of 1,000 c.c. We have three patients with vital capacities of 900, 800, and 750 c.c., living five, three, and two years after the complete closure of the cavity.

When it comes to saving life, I might mention two experiences following thoracoplasty in which the patients appeared on the verge of death. We placed them in the ordinary respirator used for cases of poliomyelitis, in one instance carrying the patient for ten days in the respirator before she would permit us to take her out. In the other instance the same thing happened. The patient seemed on the verge of death; we put him in the respirator, and he was saved.

DR. E. J. O'BRIEN.—Dr. Ornstein, I think, answered Dr. Shipman's question about cultures and what constitutes a negative sputum. What we mean by negative sputum is examination of routine and concentrated specimens over a period of a year or two without finding tubercle bacilli. It is true there are a certain number of patients (unfortunately more than we would like to have exist) in whom cultures are positive despite repeated negative concentrates. How you are going to classify them I do not know. I think it is clinically meaningless and do not hesitate to discharge such patients to their homes as arrested cases.

Dr. Bennett wanted to know what we considered a closed cavity. With negative sputum over a period of many months, and with no x-ray evidence of remaining cavity, I think you can safely assume that the cavity is closed. At least, that is what we mean by closed cavity.

Regarding routine bronchoscopy after thoracoplasty, I think I must have been misunderstood. I quoted Dr. Berry as reading a paper years ago in which he recommended this as a possibility. Is that correct, Dr. Berry?

DR. BERRY.—I do not remember that.

DR. O'BRIEN.—Anyhow, I remember, and he was way ahead of us in bronchoscopy. I do not suggest that all patients should be bronchoscoped routinely after operation. Of course not. If patients are recovering normally postoperatively, we do not bronchoscope them. If there is a sign, however, of excessive paradoxical breathing and if we think a bronchus may be occluded, or if the patient is having considerable difficulty in raising sputum, we bronchoscope him. I think we have saved many patients by so doing. We also bronchoscope every patient before thoracoplasty. I think it necessary to know whether there is a bronchial stenosis or ulceration before you drop the chest wall. We do find bronchial stenosis repeatedly, and by dilatation, get free drainage until operative procedures are finished. We have also found that many patients with bronchial ulceration were subjected to unnecessary stages of thoracoplasty because the sputum continued positive after good collapse had been obtained; some of these patients died. This tragedy can be avoided if we know ahead of time that ulceration exists.

I would like to repeat Dr. Ornstein's statement about Barnes' statistics. In this group of patients, 94.6 per cent not operated upon were dead within five years. In the group I have just reported, about 80 per cent are living today.

We seldom do the Semb operation. The results, I think, from routine thoracoplasty are sufficient. We do a Semb only if the cavity extends into the gutter. To do it routinely, I think, is adding unnecessary shock and risk to the operation.

Dr. Janes spoke about routine bronchoscopy. I think that has already been answered. Dr. Bennett spoke about statistics and how unreliable they are. I want to say that they are reliable when you use a punch system. There is no chance of personal error. You simply punch whatever you want, and shake down the cards, and your answer is there. This is the system used by us.

Now let us get to the question of a semisurgical invalid, and let's get it straight. I don't know what Bennett meant by his statement, but if an unoperated patient is lying around in a hospital with extensive cavitation, he is going to lie there and rot until he dies while supposedly under somebody's care. I don't care who is paying the bill. You also added, Dr. Bennett, and I take exception to the remark, that it does not matter that you have closed the cavity and made the sputum negative by surgery. It does matter to me. That patient lying around in a sanatorium with a closed cavity following surgery cannot pass his tuberculosis on to somebody else if his sputum is negative, but he can if it is positive. Don't tell me that they are segregated so they cannot. In any hospital, you will see visitors sitting on the beds, holding hands; and even pregnancy has occurred in our hospitals. The danger of spread with an open cavity and positive sputum is always present, and our duty to the community makes it essential that we convert the sputum in all patients as soon as possible.

Who deserves the chance of thoracoplasty? All patients in whom sputum has not been converted with more simple procedures and in whom there seems a fair chance that the operation may be safely borne, should be given this opportunity to become well. You cannot regulate health according to money; you must regulate money to suit health.

In regard to Dr. Rogers' remarks on pulmonary reserve, we spent all yesterday afternoon on that. I did not mean to convey the impression that vital capacity was our only method of determining it. If you are familiar with the work of Whitehead, in our clinic, on the oxygen saturation of the blood, you will know to what lengths we go to try to determine it. We also get the patients up to walk around before operation, and note their cardiac and respiratory reactions. We try all tests. I do not question that some people have had patients with vital capacities of 1,000 or under before thoracoplasty, and these patients are alive. It is all relative and depends upon how much you have to do to those patients to close cavities and render sputum negative. I merely made the statement that practically all patients whom we have operated upon, where the punch system showed a vital capacity under 1,000, are dead. Probably, in our group, we had to do so much surgery to close the cavities that they could not stand it. I think that answers Dr. Holman, too. Vital capacity is just one little observation. We think it is worth while, and in the future, knowing that all, or practically all, of the operated patients with a vital capacity of less than 1,000 c.c. are dead, I shall not begin an extensive thoracoplasty on patients with a vital capacity of less than 1,000 c.c.

Dr. Eloesser asked about blocked cavities. They are the bugbear of all thoracic surgeons, I think. Dr. Alexander had a very tragic case a few weeks ago of a large, blocked cavity in which thoracoplasty was done. The size of the cavity was unaffected, but the whole cavity went down and pushed on the mediastinum, resulting in death. Dr. Alexander said he thought that if he encountered this condition again, he would puncture it as you suggested in that splendid paper of yours.

EXTRAFASCIAL AIR AS AN ADJUNCT TO THORACOPLASTY WITH EXTRAFASCIAL APICOLYSIS

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IT IS common knowledge that the majority of cavernous, as well as noncavernous, tuberculous lesions occur in the upper portion of the lung. It should be equally as well appreciated that, where there is an extensive pulmonary tuberculous infection, there is necessarily considerable contiguous inflammation. It should also be borne in mind that this adjacent inflammation may involve the pleura, costal fascia, walls of blood vessels, and nerve sheaths. In our hands, extensive rib resections alone for the care of large apical lesions have often been inadequate to afford sufficient functional rest to the diseased lung tissue or to close existing large cavities. Instead of accomplishing this result, many relatively large cavities have been converted into elongated excavations because they migrated into the costovertebral gutter. The incompletely relaxed lung tissue, therefore, remained suspended longitudinally because the pleura and extrapleural fascia were densely adherent to the structures of the superior aperture of the thorax and the lateral surfaces of the bodies of the upper thoracic vertebrae.

The work and teachings of Alexander[1] and others in this country, and of P. Bull,[2] Holst,[3] and others abroad, did much to remedy this situation, for the resection of the posterior ends of the ribs, including the transverse processes, markedly increased lateral relaxation. The practice of this technique partially solved our problems but failed to accomplish the desired result in occasional instances for the reason that it failed to give sufficient relaxation from the lateral surfaces of the bodies of the vertebrae. We are now convinced that our lack of success was due, in large measure, to our failure to liberate the apical portion of the lung, along with its extrapleural fascia, from above, so as to allow it to contract concentrically toward the hilus. In other words, we failed to accomplish the same result with thoracoplasty that is often accomplished by means of artificial pneumothorax where adhesions do not exist between the parietal and visceral pleura. Various attempts have been made in the last few years to overcome this handicap. Extrapleural pneumolysis with the introduction of some foreign material in the created space has been tried both in this country and abroad. Wax,

Read before the Twenty-second Annual Meeting of The American Association for Thoracic Surgery at Los Angeles, Calif., July 5, 6, and 7, 1939.

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muscle, fatty tissue, and blood have all been interposed in the extrapleural space, but none seem to have given a true concentric relaxation as is afforded by an ideal selective artificial pneumothorax.

Approximately four years ago we began to employ, in selected cases, the "technique of Semb," hoping that it would help to solve some of our problems. Our first report of this work was at the surgical staff meeting of the Baltimore City Hospital in March, 1937. This method, namely, extrafascial separation of groups of pathologic suspensory ligaments and the upper intercostal bundles, caused the apex of the lung to drop to a lower level than was the case with any of our earlier operations. This seemed partially to solve the problem in that it gave us an extrafascial selective collapse that resembled, in some measure, the relaxation hoped for. Certainly there remained no suspension of the diseased apical portion of the lung to the separated portion of the superior bony wall of the thorax or to the "neurovascular bundle," as was most often the case with all other methods that we had tried.

In addition we found that the introduction of normal saline and the subsequent accumulation of fluid in the extrafascial apical space seemed to increase the collapse to a greater degree than we actually expected, judging from the lung level at the completion of the operation. Much to our surprise, this additional compression apparently was often sufficient to close rather large cavities. In several instances, when we believed that we had obtained adequate collapse, patients were sent back to the sanatorium, only to return several months later with the apex partially re-expanded. The lung was found to have climbed back to a higher level than the posterior end of the first unresected rib. Consequently, the cavity that was previously thought to be closed was again open, although, of course, much smaller. We felt, therefore, that if the collapse obtained by both the operation and fluid could be maintained until the tissue became fixed or until rib regeneration took place, we possibly could avoid the necessity in some instances of subjecting the patient to a second operation. For obvious reasons, this seemed highly desirable, if plausible.

The serum that accumulates in the apicolytic space, because of its slow absorption, in the presence of the altered anatomy and physiology of the upper chest wall eventually affects the functioning of the retracted and collapsed upper lobe. There develops a tendency to slowly re-expand the partially collapsed pulmonary tissue. This is brought about partly by the constant motion of the uncollapsed lung due to intrapulmonary pressure, together with the slight movement of the mediastinum and the upward movement of the shoulder girdle. In addition, if the serum is allowed to remain, there follows a gradual re-expansion of the lung, because the bloody serum will become organized and pull upward the retracted fascia, pleura, and lung. This, together with the fact that bone regeneration usually takes place after the lung has partly re-

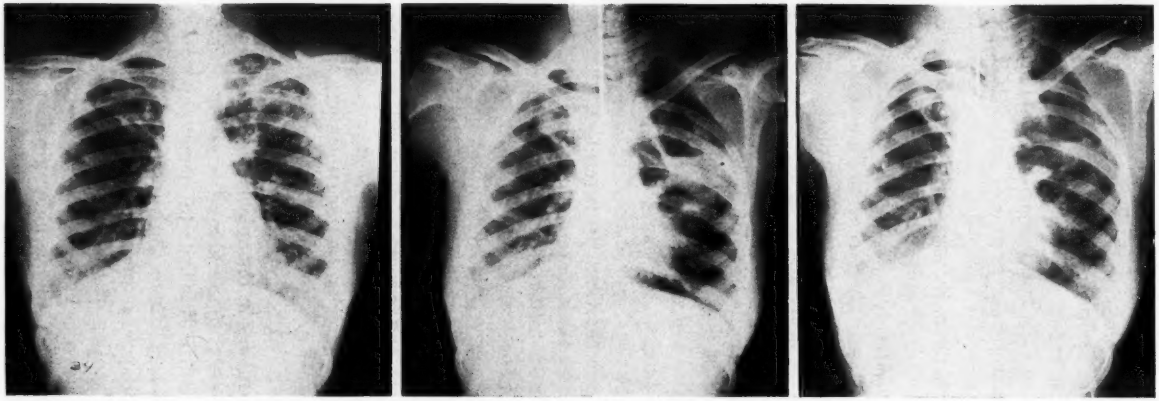

Fig. 1. Fig. 2. Fig. 3.

Fig. 1.—W. F., aged 42 years. Multiple cavitation of the left upper lobe. Three ribs were resected, without the transverse processes, on Dec. 10, 1937. Air was introduced on the sixth postoperative day.

Fig. 2.—W. F., six weeks after operation.

Fig. 3.—W. F., three months postoperatively. Bone regeneration has taken place diagonally from the level of the third rib posteriorly to the third rib anteriorly. The patient now does light work and has had negative sputum since operation.

expanded, results in fixation of the lung in a partly re-expanded state; in addition is the fact that muscle becomes reattached to regenerated bone, causing movement, and may largely negate the result of the thoracoplasty since only partially closed cavities may result. The collapse is greatest a few days following the thoracoplasty, and we feel it should be kept down if possible.

Extrapleural air apparently was used first by Tuffier in 1891, and it has been used spasmodically since that time by a number of workers, but chiefly in conjunction with apical pleurolysis and not with thoracoplasty. The work of Graf[5] and that of Schmidt[6] has revived interest in the use of extrapleural air, and they have apparently experienced success which was lacking by the use of solid material, since air is probably not as likely to injure the soft tissues.

We believe that the use of extrafascial, periosteal, and muscular air in the apical space has helped greatly in solving the problem of apical cavitation and selective collapse following thoracoplasty. In selective cases, we do an extensive resection of the first three ribs, including the second and third transverse processes, and then an extrafascial apicolysis after the method of Carl Semb. During the closure, the extrafascial space is filled with normal saline. Subsequently, on about the sixth day, fluid is aspirated from the extrafascial space and air is injected. Refills are continued at short intervals. By this method, the collapse of the apex is maintained, and often greater collapse is obtained than the number of ribs resected would indicate. It now appears that one operation will sometimes care for apical disease extending to the fifth or sixth rib posteriorly, that is, if careful postoperative treatment is carried out. The air injections are continued until the ribs have regenerated. This usually takes from two to three months. The regenerated bone, we feel, will prevent re-expansion of the apex. If the disease is more extensive and subsequent operations are necessary, they may be done as usual, but with a longer interval between stages. Thus, the time interval between stages is no longer such an important factor because this procedure keeps the apex completely pushed down and the regeneration of the ribs takes place next to the superior mediastinum. Consequently, if a second operation becomes necessary, the rib regeneration does not interfere with subsequent collapse.

Technique for Giving Extrafascial Apical Air.—If the physical condition of the patient permits, the first extrafascial air is given on the sixth postoperative day. This elapse of time allows the patient to recover from the effects of the operative procedure and, in addition, gives sufficient time for the extrafascial apical space to seal off. This sealing off process resulting from tissue reaction makes the space almost air-tight; consequently, there is only slight evidence of emphysema of the surrounding tissues following the air injection.

For ease of finding the extrafascial apical space at the time of the first injection, the needle is inserted one and one-half inches lateral to the sternum in the

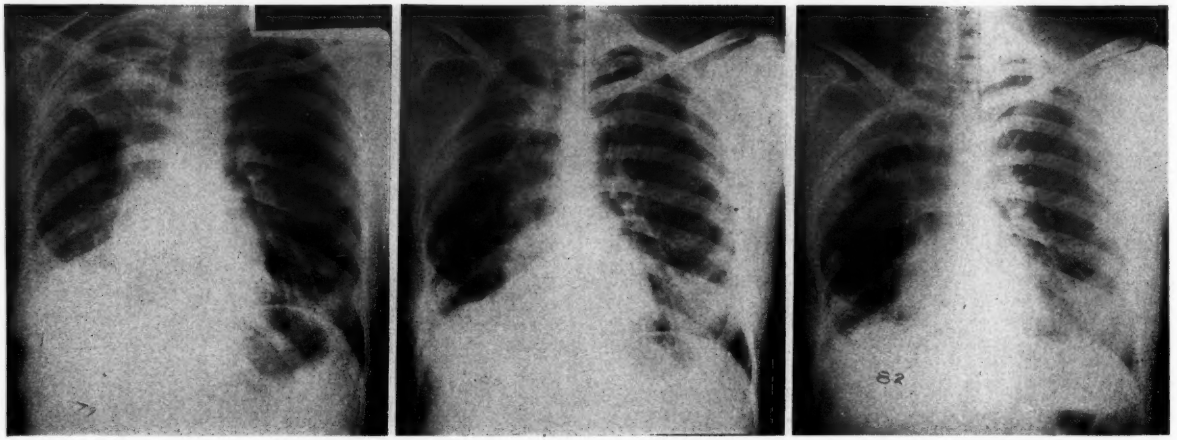

Fig. 4. Fig. 5. Fig. 6.

Fig. 4.—W. M., aged 34 years. Contractile type of tuberculosis of the right upper lobe extending to the sixth rib posteriorly. Three ribs were resected in August, 1937, without removing the transverse processes. Air was injected on the sixth postoperative day and continued for three months.

Fig. 5.—W. M., three months later. Air pocket and rib regeneration.

Fig. 6.—W. M., showing end result one year later. The patient has remained well and has been working since that time.

region of the removed second rib. In all future refills, the needle is inserted from above just medial to the acromion process and dorsal to the clavicle. This site is selected because the insertion of the needle from the front may penetrate lung tissue and the introduction of the needle from behind may traverse unsuspected infection existing in the wound. By inserting the needle from the top of the shoulder and staying posterior and lateral to the subclavian artery and vein and the brachial plexus, the needle should not enter pulmonary tissue, traverse the operative wound, or injure any important structures.

The location of the proper extrafascial space is determined unmistakably by withdrawing fluid. This fluid varies from serum to old blood. The amount of fluid that is easily aspirated is withdrawn. As the fluid is aspirated, it is replaced with air, so as not to lose the space. All the extrapleural fluid need not be withdrawn necessarily although most of it should be. The aspirated fluid should be cultured, however, in order to properly place the blame if infection of the extrapleural space should develop.

The refill interval, the pressure, and the amount of air injected are governed by the amount of pulmonary fibrosis and the desired collapse. Patients' lungs with considerable fibrosis are usually more difficult to collapse. Refills at three-day intervals, using 20 cm. of water as the final pressure, usually are sufficient in the beginning. Once the desired collapse is obtained, the refill interval may be lengthened.

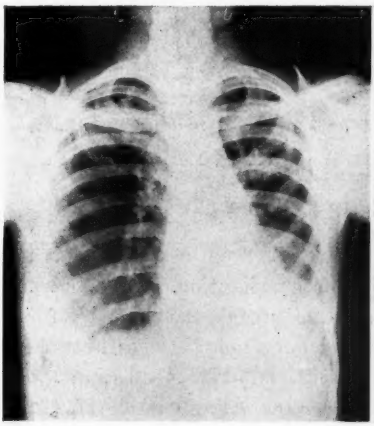

Fig. 7.

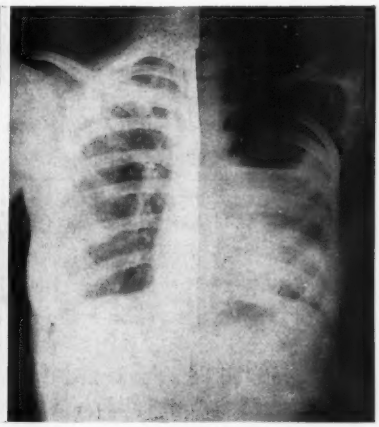

Fig. 8.

Fig. 7.—F. C., aged 30 years. Large cavity of the left upper lobe reaching to the sixth rib posteriorly. The upper three ribs, including the second and third transverse processes, were removed Nov. 29, 1938. Air was injected routinely six days postoperatively.

Fig. 8.—F. C., showing air pocket four weeks later. The patient was transferred to the sanatorium, and the injection of air was abandoned.

If more collapse is desired, it is better to give more frequent refills than to increase the pressure above 20 cm. of water. The initial pressure in the extrafascial apical space is usually zero when refills are given at three-day intervals. There is some fluctuation of pressure on inspiration and expiration, but not nearly as much as is noticed during refills with intrapleural artificial pneumothorax.

The only necessary equipment is a long 20 or 22 gauge needle, a three-way stopcock, syringe (20 or 50 c.c.), and a simple water manometer. Our experience has shown that the usual types of pneumothorax machines will not deliver enough

pressure. Since only a small amount of air is injected (40 to 150 c.c.), injection by the syringe method has proved satisfactory.

Our experience with this procedure is somewhat limited and we are not advocating it as a panacea. There have been complications, one sudden unexplainable death and one air embolus that did not prove

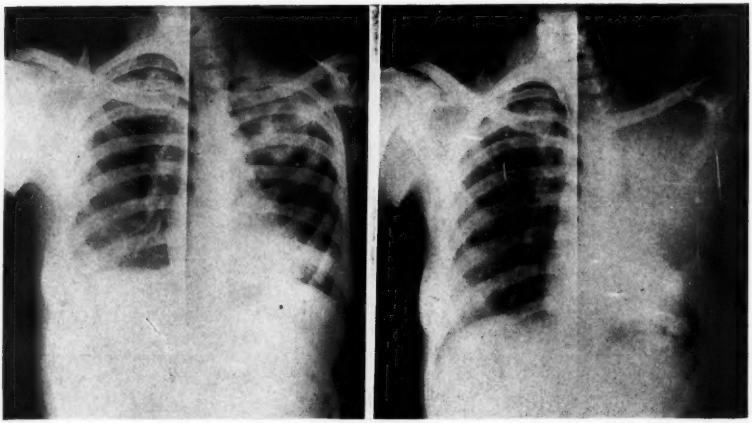

Fig. 9. Fig. 10.

Fig. 9.—F. C., five months later, March 20, 1939. Partial re-expansion with open cavity.

Fig. 10.—F. C., following second-stage operation March 25, 1939. Three additional ribs, including the transverse processes, were resected.

fatal. We feel that these two cases were due to faulty technique. We do feel, judging from forty cases we have observed closely, that it accomplishes two things that are worthy of consideration. First, in some instances it helps to close large cavities and avoids the necessity for a second operation. Second, if the second operation becomes necessary, the regenerated bone is pushed up against the superior mediastinum in a concave position rather than a convex one, as is the case without air. This factor enables us to delay the second operation for months, if necessary. This increased period allows the patient to recover from the first stage before having to undergo the second strenuous ordeal and helps to stabilize the mediastinal structures. The latter factors, we believe, will materially lower the operative mortality following the second stage.

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DISCUSSION

DR. FRANK S. DOLLEY, Los Angeles, Calif.—Dr. Aycock's results by the use of air to maintain apical collapse after extrafascial apicolysis in conjunction with upper rib thoracoplasty are excellent.

All of us have been repeatedly concerned to find that a lung freed extrafascially to the third or fourth interspace during an upper stage thoracoplasty, had, at the time of the second stage, returned nearly to its preoperative position. Manifestly, Dr. Aycock's method of using air postoperatively to maintain apical collapse has proved very satisfactory in his hands and those of his associates.

As both Dr. Hudson and Dr. Head stated in their discussions, so Dr. Jones and I have felt from the earliest days of extrafascial apicolysis that apical lysis should not be done routinely as an integral part of every first-stage thoracoplasty. With cavities located laterally, it is advisable, we feel, to allow the apex to remain attached in its normal position, thus depending upon lateral pressure to bring about cavity closure, rather than assuming the risk by extensive apicolysis of dropping the cavity walls downward and inward toward the hilum, where, in its new position, and only partially collapsed, it becomes inaccessible to further thoracoplastic pressure except by the sacrifice of a very considerable area of uninvolved lung as additional lower rib-sections are removed.

When extrafascial apicolysis seemed the procedure of choice in a given case, we routinely closed the wound without drainage. The accumulated serum served as somewhat of a restraining factor in controlling apical re-expansion. On the occasion of the second stage, however, we still found that the lung had returned up the mediastinal wall toward its normal anatomic position. Recently, at the time of closure, we have left in this extrafascial space from 80 to 100 c.c. of olive oil which we removed at the second stage. This, plus serum accumulation, accomplished apical maintenance surprisingly well. The barrier between the two stages is removed, and an excellent collapse is obtained.

Dr. Head reports that he has found the use of solid material valuable for this purpose. It seems to me that the danger of infection or of pressure necrosis into the lung would be greater than with air or oil. I shall be interested to hear of his further experience with it as his series increases.

I feel very definitely too that, even with well-maintained apical lysis, it is seldom safe to limit a thoracoplasty to the upper three ribs. The removal of two more at a second stage does not produce an appreciable deformity and certainly offers more assurance of permanent cavity closure.

A final word concerning Dr. Aycock's procedure. It seems to me more than likely that eventually, provided he determines the use of air particularly satisfactory, he will find extrapleural pneumothorax technique with early oil conversion fully as gratifying. Thus, he might obviate the necessity for thoracoplasty at all.

DR. L. J. LEAHY, Buffalo, N. Y.—Undoubtedly, we all have slight personal variations in the technique of performing a thoracoplasty. In doing the first stage, it has been my habit to remove the third and the second ribs, and following this, to perform the apicolysis with the first rib intact. The reason for this is that we feel the extrapleural separation of the apex is more easily accomplished

with the first rib in place, and, secondly, that the first rib can be more readily removed with the apex out of the way. Following apicolysis, a warm, moist pack is placed on the apex which is held down by gentle pressure during removal of the rib.

The reason for describing this variation in technique is that it leads up to the case which I wish to mention. This is one of a 25-year-old female who had a cavity in the right apex and positive sputum. Artificial pneumothorax was attempted and found to be impossible. Thoracoplasty was obviously the treatment of choice, but it had been deferred elsewhere because of a cardiac condition. Her vital capacity was 1,966 c.c. with a standard of 3,160. We felt that her persistent open cavity presented much more of a hazard to her health than her cardiac condition, and on Oct. 15, 1938, a right upper stage thoracoplasty was done under cyclopropane anesthesia. The second and third ribs were removed in their entirety, and an apicolysis was performed preliminary to removal of the first rib. The anesthetist commented that she was beginning to show cyanosis despite a high percentage of oxygen, so the muscles were reunited and the wound was closed. We wished at the time that the first and second ribs were out rather than the second and third. With the first rib still intact, it was felt that re-expansion was quite likely to take place; to overcome this complication, it was decided to treat her postoperatively as an extrapleural pneumothorax. There was paradoxical respiration present which also influenced us in this regard as we felt that the injection of air might stabilize the mediastinum. Three hundred cubic centimeters of air was introduced through the first interspace, anteriorly. This gave a pressure of −2 and +9. The patient commented that she could raise her sputum more easily following an injection. There was a postoperative rise of temperature to 102° F. for three days; with the exception of this, convalescence was uneventful.

Refills of air were given about every other day until it became necessary to give them only weekly. The largest amount given was 450 c.c., and the highest pressure obtained was +12, at which time there was some fluid, which eventually absorbed, present in the space. The small amount of interstitial emphysema in our case was remarkable when one considers the large paravertebral incision. Despite what appeared to be a very successful extrapleural pneumothorax in combination with a partial thoracoplasty, her sputum continued positive, and on January 4 a second-stage thoracoplasty was done. At this time, there was a fairly large extrapleural space which was completely lined with a smooth membrane, but which contained no fluid. The apex was well down to about the level of the fifth rib. The first rib was removed without any difficulty as were the fourth and fifth; further apicolysis was done down to about the seventh rib. Following this, there was no postoperative elevation of temperature. She had an uneventful convalescence, and her sputum became negative and has remained so.

This case impressed us with the feasibility of combining the extrapleural introduction of air with a first-stage thoracoplasty and apicolysis. The height of the apex was rather easily held down, and the mediastinum was stabilized. It interfered in no way with the second stage; in fact, it made it easier. On the other hand, it subjects a patient to the complications of extrapleural pneumothorax in addition to those of thoracoplasty. I cannot help but feel that it produces a space by ballooning out the soft tissues that would favor re-expansion following discontinuance of the air, because the soft tissues would be more rigid than they are ordinarily following a thoracoplasty and would have less tendency to fall in and obliterate the space created by the operation. Although this procedure was extremely satisfactory in our case and we planned on using it in future cases when indicated by some such complication as paradoxical respiration, I did not plan to institute it as a routine procedure.

DR. ALFRED GOLDMAN, SAN FRANCISCO, CALIF.—I enjoyed Dr. Aycock's presentation and think his method is an excellent means of holding the apex down. The next step is to determine the indications for this procedure. In the last case which Dr. Aycock demonstrated, the cavity reappeared after the first stage, although there was no air injected. In Dr. Brunn's clinic, we have accepted the appearance of such a cavity as an indication of tension or "blocked cavity," as Dr. Eloesser terms it. The reappearance of this cavity after thoracoplasty is probably associated with failure of the bronchus to act as an efficient airway, rather than with failure of operative technique. Recently, in studying pressures in cavities, we devised a test which is similar, in a way, to that applied by Dr. Eloesser to determine whether or not the bronchus leading to such a cavity is patent or closed. In this test, a needle is introduced into the cavity and pressures are marked on the moving kymograph drum after the trocar or needle is connected in different phases of respiration. When the apparatus is connected at the height of inspiration (in this maneuver the trocar is connected with the atmospheric air), air is sucked into the cavity and "paradoxical" pressure—that is, positive pressure during inspiration when the system is closed—is maintained. In the face of these readings, we believe that the bronchus which should serve to drain the cavity is obstructed. On the other hand, when the needle is connected at the height of expiration, a negative pressure (paradoxical) is maintained in the cavity with subsequent respiration. Different behavior of the pressures within the cavity was obtained when this test was performed on a cavity with an unobstructed bronchus.

DR. THOMAS B. AYCOCK.—I appreciate the discussion. I feel, however, that the cases in which extrafascial apicolysis is done should be approached very cautiously. I am not entirely sold on the idea because, in my own experience, the general hospitals where the surgery is done and the tuberculosis sanatoriums are separated, and I have not, in every instance, been able to follow these patients closely. Many of the patients in whom it has been tried have fallen into the hands of those who are comparatively inexperienced in surgery. Many cases have failed entirely. These forty patients, that I mentioned, however, were treated in the general hospital for some time following operation or were transferred to Mount Wilson Sanatorium, which is located only a few miles from Baltimore. Judging from these few, I am convinced that the procedure has some merit, but I do feel we should approach it cautiously and be reluctant to force air into the extrafascial space under too much pressure, for I feel that complications, such as bronchial fistula and infections, will too often result.

FOUR YEARS' EXPERIENCE WITH EXTRAPLEURAL PNEUMOTHORAX AND OLEOTHORAX

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SEATTLE, WASH.

SOME ten years ago my interest was aroused in finding a means of localized compression, either temporary or permanent, of a small area of the lung. It seemed that many otherwise hopeless cases would be offered some chance if there were such a procedure. It was at about this time that gauze packing, rubber dam, and rubber balloons were being used, and paraffin was again brought forward as a means of accomplishing this result.

From considerable observation of paraffin in human tissues, I could not bring myself to use it, and I attempted to find some more suitable material. Although various substances were considered and some used, none seemed the proper filling. It had been suggested that after pneumonolysis the lung or cavity, at this point, would stay compressed if nothing were put into the space. Accordingly, some six years ago this was tried, but it was found that after variable intervals re-expansion eventually took place. The idea then occurred to me to keep introducing air under pressure into this space to keep the lung compressed, and for over four years, I have been using this method. Soon after, I had occasion to fill some of these spaces with oil, so that experience with this substance extends over almost as long a period.

Space will not permit review of a history of this procedure. After having used it for two years, I found that as long ago as 1913 Mayer* had employed it in a few cases, because he too felt it wrong to use paraffin because of observation and experiments on rabbits.

While the method has been discussed on various occasions, no report has been published. It had been the original intention to wait three or four years and to attempt to determine its merits over a period of time. Its use has not been indiscriminate; it was used only in those particular instances where it offered some special advantage. While this series of forty-four cases is not large, some definite conclusions have been reached in these last four years, and I am pleased to have the privilege of presenting them to you.

INDICATIONS

An attempt has been made to be very conservative in the selection of cases for this procedure, and to avoid being carried away by enthusiasm, to the detriment of the patient. All cases have had a

Read before the Twenty-Second Annual Meeting of the American Association for Thoracic Surgery at Los Angeles, Calif., July 5, 6, and 7, 1939.

*Mayer, A.: Deutsche med. Wchnschr. 39: 2347, 1913.

thorough trial of medical management, the length of time depending upon the pathology present and the response to treatment. Where considerable cavitation was present and it was obvious that no progress was being, or would be, made, no further time was lost in applying more active measures.

Intrapleural pneumothorax has been attempted in each instance and found either impossible or unsatisfactory. In a large number of the cases, extensive apical disease prevented compression, although a perfectly satisfactory collapse was obtained in the less involved portion. The lung has been allowed to re-expand before attempting this procedure.

While I believe in the value of paralysis of the diaphragm, either permanent or temporary, as a therapeutic measure, there are a number of cases in the series in which such paralysis was not sufficient to compress the lesion adequately, or was contraindicated because of the disease's being limited to the apex, with the greatest portion of the lung apparently in good condition. I hesitate to establish a temporary paralysis in the latter cases, because often the time allowed by such method is not sufficient for healing, even in those cases where compression is successful; and, furthermore, a certain percentage of these diaphragms remain paralyzed no matter how carefully one handles the phrenic nerve. A few of the patients in the series have had permanent phrenic interruptions which were done many years ago and which were not adequate to put the lesions at rest, or they have had a relapse despite the phrenic operation.

Extrapleural pneumothorax has not been used where it was felt that thoracoplasty would accomplish the same result. However, I have had numerous cases with large, or even giant, apical cavities (Fig. 1) in which no procedure with which I am familiar would completely obliterate the cavity. Almost all of us have seen cases with the most extensive thoracoplasties in which the end result has been a permanent smaller cavity. For these cases, this operation seems much superior to thoracoplasty. Large bilateral cavities may also be treated by this method (Figs. 2 and 3), one side being compressed and held at a satisfactory point for a time before the other side is attacked.

There have been a number of instances in which a small lesion or cavity in one apex has resisted all forms of treatment, and in which a thoracoplasty in order to compress the area adequately would necessarily destroy a very considerable portion of the lung on that side. Here extrapleural pneumothorax may be carried out, and the pocket can be brought to the size which will have the greatest effect upon the diseased area with the least amount of compression of good lung.

My interest in finding some such procedure as this was first aroused by the case of a girl who had a small cavity in the right apex, with

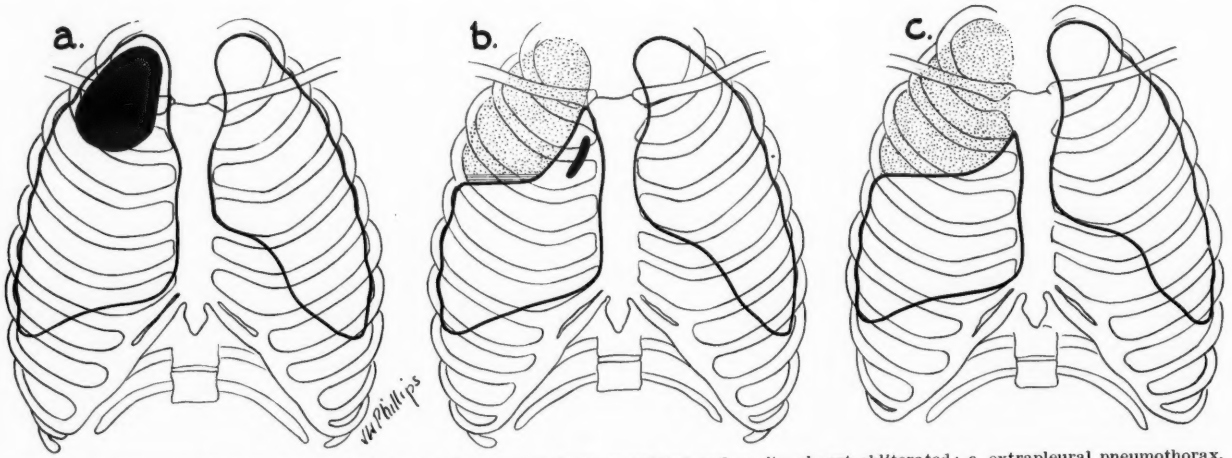


Fig. 1.—*a*, Diagram showing huge apical cavity; *b*, pneumonolysis completed and cavity almost obliterated; *c*, extrapleural pneumothorax, with cavity entirely closed.

very extensive disease of the entire left lung. It did not seem justifiable to do a complete left thoracoplasty in the presence of the cavity in the right apex. To compress this cavity adequately by thoracoplasty on the right meant too much destruction of the lung to be compatible with any activity other than permanent invalidism in bed, if

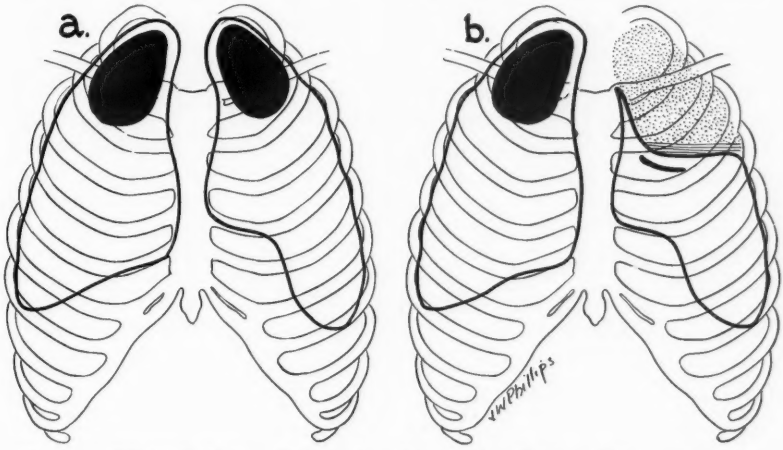


Fig. 2.—*a*, Bilateral giant cavities in apices; *b*, extrapleural pneumothorax on left, with closure of cavity.

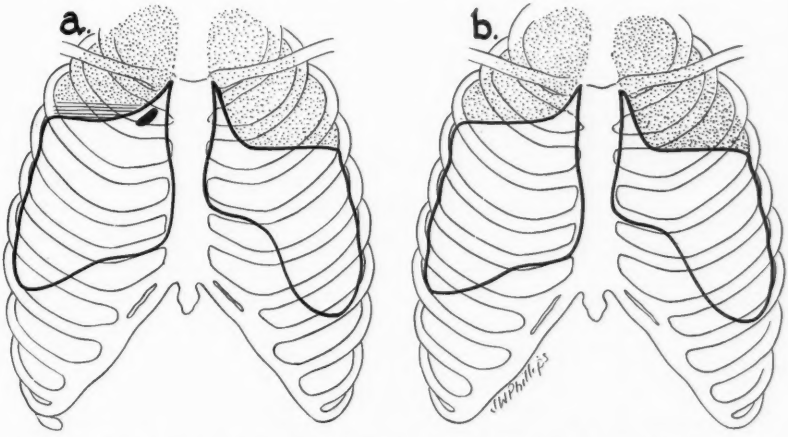


Fig. 3.—*a*, Extrapleural pneumothorax on right, with cavity practically closed; *b*, bilateral pneumothorax, with both cavities obliterated.

indeed she were left with enough lung to carry on her existence. In such a situation, one may form the extrapleural pocket with a minimum loss of breathing space, and subsequently proceed with a complete thoracoplasty on the opposite side.

Then there is the problem of an isolated cavity or diseased area in any part of the lung (Fig. 4), with the balance of the lung apparently in good condition. A thoracoplasty means, of course, putting the lung completely and permanently out of use, and destroying 80 per cent or more of good breathing space in order to reach the 20 per cent or less of disease. There is the possibility that the infection may flare up on the opposite side. Here it is possible to exert a more or less localized compression which will prove adequate and still leave ample breathing space on that side. Again one may do an extrapleural pneumothorax of an even more extensive area or of the whole lung and still allow re-expansion if necessary, giving the patient a chance which would otherwise be unavailable.

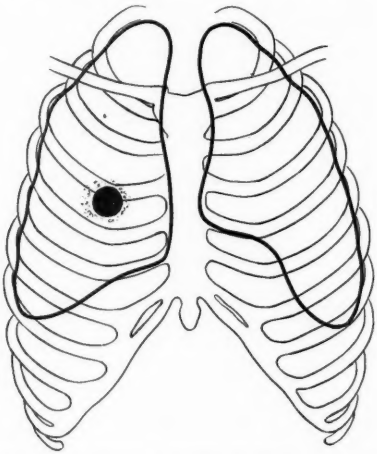


Fig. 4.—Diagram illustrating isolated cavity in the middle of one lung.

There are other instances in which thoracoplasty is contraindicated for one reason or another. I shall not attempt to enumerate the conditions where such is the case, but all of us, I am sure, occasionally encounter a case which could not stand a thoracoplasty, or in which there is some definite contraindication. Very often, in such cases, extrapleural pneumothorax will save the patient.

TECHNIQUE OF THE OPERATION

Space does not permit a complete description of the technique which has been evolved, together with the illustrations. This will be dealt with more fully in a separate article. The approach will depend upon the extent and location of the disease. For the apical lesion, which is most common, I favor a posterior approach with adequate exposure to enable the subperiosteal removal of at least a four-inch portion of the fourth or fifth rib, from the transverse process of the vertebra outward. There is no disadvantage to a reasonable incision, and I feel it is essential to have ample room to work. Should one run into dangerous bleed-

ing, he would be helpless with a small opening, and the patient's life jeopardized or lost. Fortunately, I have had no bleeding of any consequence.

An incision is made in the periosteal bed of the rib, and a plane of cleavage is found under this which will enable separation of the parietal pleura from the endothoracic fascia. As a general rule, this is not difficult, and the dissection is carried out mostly with the fingers; soon there is a good-sized space in which to work. In those cases where the parietal pleura is not very adherent to the chest wall, it may be possible to carry out the entire operation with finger dissection. Where the pleura is firmly adherent as the result of inflammation, it is sometimes necessary to use sharp dissection in freeing it from the chest wall. Occasionally, wiping with a small dry sponge will suffice to free the pleura instead of cutting with instruments. The apex may be thoroughly freed, and the lung compressed to any desired level.

From the first I have used a Cameron light for illumination, and I have found it satisfactory and adequate. One may use a band retractor to hold down the lung and obtain exposure and good visualization of the extrapleural space during the operation. At the completion of the pneumonolysis, there is usually some oozing from the inside of the chest wall. This can be controlled readily by hot sponges. Any small point which continues to bleed may be coagulated with the radio cautery, with care not to use it in proximity to the large mediastinal vessels or the lung.

The closure is effected with chromic catgut, with the periosteal bed and the intercostal bundles sewed together in one mass. Prior to closing this opening, No. 3 or 4 chromic catgut sutures are placed around the ribs next above and below, and they are tied as the muscle suture progresses so that they allow closure without tension and without leakage. The line of suture should be almost completely airtight in order to carry out the extrapleural pneumothorax. Where there is a large cavity present, especially one near the surface, the extrapleural space is filled with salt solution just before the intercostal bundles are completely closed, primarily for the purpose of splinting the lung. The muscles of the chest wall are sewed together with chromic catgut, and the skin is closed with dermal.

PITFALLS

The dangers at operation come under five headings principally:

a. Puncture Into a Cavity.—Some of these patients have enormous cavities which are extremely thin-walled, and it is necessary to use great care not to puncture into the cavity or the lung, as this obviously would lead to a mixed infection of the space, with very serious consequences. It would necessitate termination of the operation at this point; if the patient survived, a thoracoplasty would be necessary, with good chances of a permanent fistula. It is surprising how a pneumonolysis can be done in a case in which the cavity seems to extend completely out to the chest wall and the x-ray gives no indication of any lung tissue whatsoever between the parietal pleura and the inside of the cavity.

It has been said that a cavity of the size and location described is an absolute contraindication to extrapleural pneumothorax. I have not found this so, for it is particularly these giant cavities which are almost impossible to obliterate by any other method; although I have encountered a number of them, I have been fortunate enough not to open into any.

b. Tear Into the Free Pleural Space.—Twice in this series the free pleural space has been opened, despite the fact that repeated previous attempts at pneumo-

thorax were unsuccessful. In each instance where the free pleural space was opened, there was a very considerable collapse of the lower part of the lung. An attempt may be made to sew this opening, so as to separate the extrapleural and intrapleural spaces, but the chances of success are slim. There is the alternative of abandoning the operation, whether complete or incomplete, or possibly of converting the situation into a combined extra- and intrapleural pneumothorax, with the hope that later the lower part of the lung will expand and become firmly adherent, leaving a selective collapse of the apex. These patients usually have a very considerable reaction, which is not always easy to explain, for a few days or more, but they have all recovered.

c. Hemorrhage.—I have been fortunate in not having any hemorrhage at operation, but one must be on guard for it constantly, for in working in close proximity to the large mediastinal vessels, it is always possible to tear into one of them in separating the pleura. With due care, serious hemorrhage should be very rare. The surgeon must exercise great caution in stripping away the pleura at the apex, as well as from the mediastinum; and if it is at all adherent in these areas, he must use dissection under direct vision. It is usually neither wise nor desirable to free the pleura completely from its mediastinal attachments if it is firmly adherent there. The danger of tearing a large vessel is considerable, and complete separation is not essential for a good result.

d. Rapid Compression of the Diseased Lung.—None of the patients in this series seems to have suffered any deleterious effects as the result of compression of a very considerable area of the lung at one operation. In some instances, almost the entire lung has been compressed, and still there has been no great reaction or any other unfavorable effect. It is highly desirable, of course, if not actually essential, to complete whatever compression is expected in one stage, and it has been very gratifying that no serious consequences have followed. However, it is always possible that one may have a case in which rapid compression of an extensively diseased lung may have a grave outcome.

e. Pyogenic Infection.—As with any operation there is always the danger of introducing infection, and one must be most careful to guard against this complication. The upper mediastinum is entirely unprotected, and a closed cavity partly filled with bloody serum affords an ideal culture medium. This misfortune has not happened in this series, but it is one of the hazards to be watched.

The potential danger immediately postoperative is either a blowout of a large cavity into the extrapleural space or necrosis of the cavity wall. One of the patients in this series had a huge cavity which was successfully stripped from the chest wall and intact at the time of closure. It was, I am confident, opened by the coughing of the patient, there being nothing to hold the cavity down during coughing other than atmospheric pressure. Any of these thin-walled cavities could be ruptured in a fit of coughing, or there may be a weak spot through which a blowout occurs just as it does with an inner tube. I believe that filling the extrapleural space with normal salt solution to act as a splint will prevent such complications.

Necrosis of the cavity wall from lack of blood supply is mentioned as one of the hazards, but I have not encountered it so far. Despite the size of the cavities, they apparently have sufficient blood supply from the balance of the lung and the visceral and parietal pleurae to prevent a necrosis of the wall in most instances. The only exception would be in the case just mentioned. I believe this was a blowout from cough, but I cannot disprove the possibility of a necrosis of the cavity wall.

NORMAL COURSE

Following operation there is a greater or lesser accumulation of serosanguineous fluid from the extensive raw surface which is left. Sometimes this is inconsiderable, and at other times it fills almost the entire space. This fluid is aspirated and replaced with air at atmospheric pressure within from five to seven days after operation, provided there is any amount of it. A small collection will be absorbed over a period of time, and it is difficult to reach.

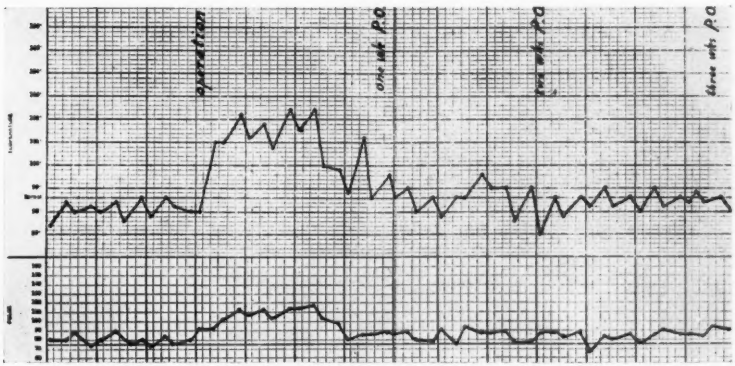


Fig. 5.—Composite of a number of charts, showing typical postoperative course.

After the first pneumothorax is given at the end of five or seven days, it is repeated every two or three days, depending upon the x-ray or fluoroscopic appearance, and a neutral pressure is maintained for the first ten to fourteen days. Then, gradually, higher pressures are used, so that at the end of about three weeks one may be using from 8 to 10 cm. of water pressure. It is inadvisable to increase the pressure too fast for fear of a small blowout through the line of suture. After approximately three weeks, however, one may begin to use higher pressures, for by this time, the incision into the chest wall is usually tightly healed. From this time on, pneumothorax is given approximately twice a week for a month or more, with the pressure gradually increased to attain and maintain the desired result. The amount of air injected ranges ordinarily from 100 to 300 c.c., depending upon the size of the extrapleural space. Such refills are given usually twice a week, decreased to weekly intervals, and finally given at intervals of from two to three weeks. At the end of the time interval, the pressure in the space must be found to be either neutral or slightly positive; otherwise, one runs the risk of the lung's expanding and the space's being partially or wholly lost. Should one find a negative pressure, the interval between refills should be shortened.

It is found that it is generally necessary to use progressively higher pressures to put in the same amount of air from time to time. Where, at the end of four weeks after operation, one can introduce 300 c.c. of air under pressure of 8 cm. of water, after eight or ten weeks it may be necessary to use pressures as high as from 50 to 100 cm. of water. Frequently it has been observed that, if these higher pressures are not used, the lung tends to re-expand. In addition, one may find that a cavity or diseased area is not entirely compressed, or is not held down as desired. In such cases I have carried the pressure as high as 130 cm. of water in order to achieve and maintain the desired result.

COMPLICATIONS

a. Purulent Effusion.—There may develop, sooner or later, a purulent effusion into the space. It may be sterile and symptomless, repeated smears and cultures revealing neither pyogenic organisms nor tubercle bacilli. There may be no fever or other reaction from the presence of this purulent effusion. In one patient it was present for a year, and the pus was identified only because it was felt advisable to investigate a fluid level which had persisted this length of time and had failed to be absorbed.

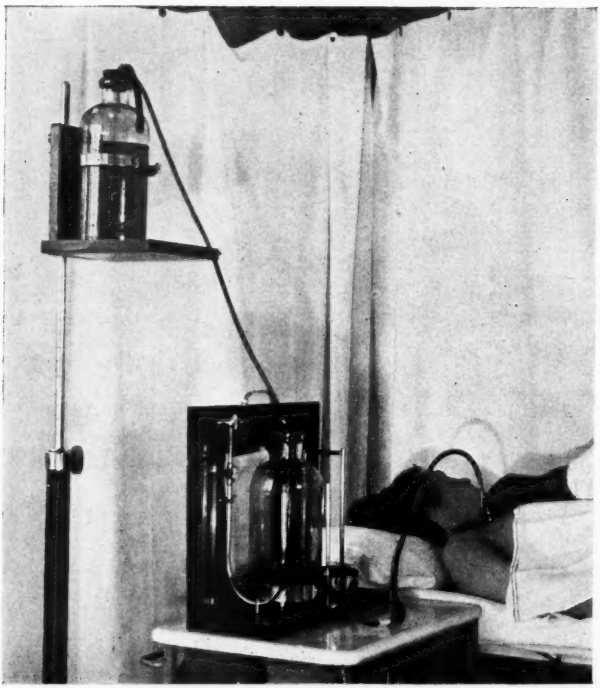


Fig. 6.—Photograph showing administration of extrapleural pneumothorax under high pressure.

b. True Tuberculous Empyema.—Most of the purulent effusions into the extrapleural space will be found to be true tuberculous infections, with tubercle bacilli present either in smear or culture. They may become evident soon after the operation, from some tuberculous focus on or near the surface of the lung, or they may be delayed in appearing. They may also occur after a very considerable interval by extension of the disease from the remaining lung to the extrapleural space. While these are true tuberculous empyemas, they seem to be a much more benign process than that which occurs intrapleurally. If the space is kept washed out and clean with normal salt solution or some mild antiseptic, the patient's temperature rapidly becomes normal and remains so, and his general condition seems excellent. From here on, one may be able to continue the pneumothorax or to convert it, as has been the usual practice, into an oleothorax.

c. Blowout of Extrapleural Space.—Higher air pressures may find some small weak point in the scar of the closure of the opening into the chest wall and cause a blowout into the subcutaneous tissues. This is serious in that it forces abandonment of the extrapleural pneumothorax. In addition, unless great care is exercised, the air may work its way through to the scar in the skin and rupture it, causing an open communication between the pocket and the exterior. Because of the considerable increase in scar tissue formation due to oil, it occurred to me that a small blowout might be plugged by instilling a little oil into the extrapleural space. In the one case in which I had an opportunity to try it, the hole in the extrapleural pocket was successfully closed. Following this, the space was filled with oil, but I believe that one might plug the hole so that pneumothorax could be continued, provided the pressures required were not too high.

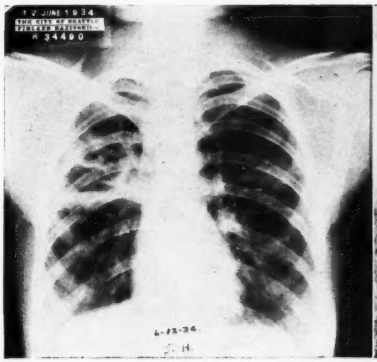


Fig. 7.

Fig. 8.

Fig. 7.—J. H., roentgenogram before operation. Large cavity and disease involving entire upper half of right lung.

Fig. 8.—J. H. After two and one-half years of extrapleural pneumothorax.

d. Reaction to High Pressure.—Very rarely, when high pressures up to 130 cm. of water, which is the highest pressure I have attempted to use, are being employed there occurs a reaction to the high pressure. This is apparently caused by compression of the mediastinal vessels, with alarming cerebral symptoms which may be promptly relieved by release of the pressure. This has happened only twice in many hundreds of refills. A patient may be given pneumothorax for a year or two years without the slightest difficulty, and then, suddenly and immediately following the refill, the reaction occurs, usually from some change in position. In one patient with an extrapleural pocket in the right apex, there was dizziness, faintness, and marked pallor, accompanied by numbness and weakness in the left arm and leg, an imperceptible pulse, and complaint of failing vision. Air was removed from the space, and in a few minutes the entire picture had cleared and the patient was able to go home unassisted. The only plausible explanation in this instance would seem to be a sudden compression of the right innominate artery.

e. Pyogenic or Mixed Infection of the Space.—With care, any pyogenic infection of the extrapleural space introduced through the refills should be extremely rare. We have not experienced this. A mixed infection could also occur conceivably, but the only purulent effusions present in this series have been sterile or tuberculous.

f. Air Embolus.—It is always possible that one may have a case of air embolism. One is working in a space which frequently is relatively small and must, there-

fore, be extremely cautious as to the position of the needle. The reading of the manometer will give assurance of being in the space just as in an intrapleural pneumothorax, but great care must be exercised that the needle does not change its position during the injection of air, as it could easily penetrate the lung without the situation's being recognized and cause a fatal embolus. I do not believe that there is any danger of rupturing into the lung with pressures up to 130 cm. of water, because, by the time that such pressures are used, there is a very considerable amount of scar tissue in the walls of the space which can readily withstand this much or more.

OLEOTHORAX

Extrapleural pneumothorax in the majority of cases in this series has been converted into oleothorax. This has been done for a number of reasons, including the underlying pulmonary pathology, the conditions encountered during pneumothorax, the social status of the patient, and development of empyema. Where an apical cavity of any consequence has existed, or where the apex of the lung has been extensively diseased with or without cavitation, it is felt that this part of the lung should be kept permanently compressed. Consequently, oil was used in some of the early cases, and this procedure has been continued since. Either olive or paraffin oil may be used with or without the addition of gomenol. We have preferred olive oil with two per cent gomenol, but in many instances it may be preferable to use mineral oil to obviate ever having to refill, or add to, the oleothorax.

When it is decided to use oil, the extrapleural space is filled in three or four sessions, depending upon the size of the space, and additional oil may be added from every six to twenty-four months. The absorption of olive oil is very slow, and some cases in the series have not had any additional oil put in. With the use of mineral oil, of course, there is no necessity for subsequent filling.

Where it is intended from the start to use oil as a permanent means of keeping a localized area of lung compressed, one proceeds to establish an extrapleural pneumothorax, and then, two or three months later, after the extrapleural space is of exact size and location desired, it is filled with oil. The extrapleural space may be varied in size by the amount of pressure used in the refills. The best procedure is to make the original space larger than one contemplates leaving it, and with the use of less pressure, the lung will re-expand to the point where it is desired to keep it. By this time, the extrapleural space is dry and in good condition to receive the oil. If it is found that compression is not quite adequate, more frequent refills and higher air pressures may be used, until the extrapleural space is of the extent desired. The amount of additional compression that may be obtained by this means ordinarily is not very great, so that it is better to be able to allow the lung to expand to the desired extent, rather than to have to compress it further.

Oil may be introduced under pressure. In one case of the series I have had experience in obtaining increased compression after initiating an oleothorax by introducing oil under slightly increased pressure. It is somewhat difficult to measure oil pressure accurately, but by

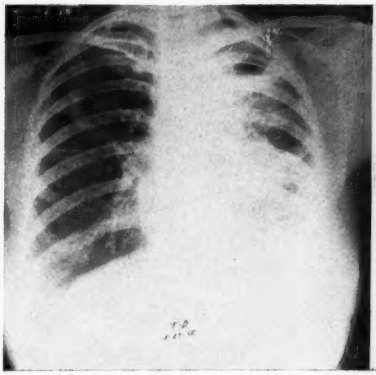


Fig. 9.

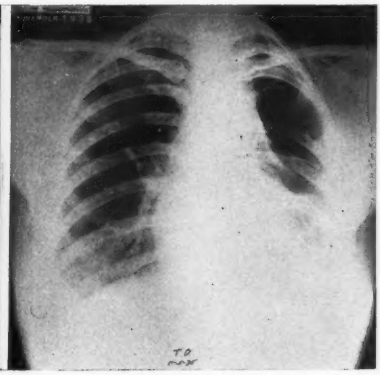


Fig. 10.

Fig. 9.—T. D. Roentgenogram made May 5, 1935, immediately prior to operation. Large cavity at left apex.

Fig. 10.—T. D. Nov. 5, 1935, after six months of extrapleural pneumothorax.

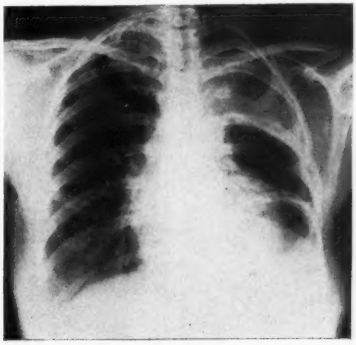


Fig. 11.—T. D. June 1, 1939, after six months of extrapleural pneumothorax and three and one-half years of extrapleural oleothorax.

using two needles and introducing oil through one, leaving the other as a safety valve, from 10 to 30 c.c. of additional oil has been introduced into the pocket under slight pressure, with a definite decrease in the amount of sputum and with other evidences of improvement.

ADVANTAGES OF EXTRAPLEURAL PNEUMOTHORAX

First should be mentioned the compression of a localized diseased area with minimum loss of function of the remaining lung. This is

highly important to all persons who have come to surgery for their tuberculosis, particularly those who have had, or who still have, more or less obvious involvement of the other lung. Should the disease flare

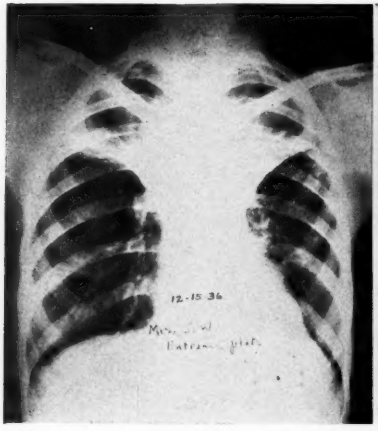


Fig. 12.

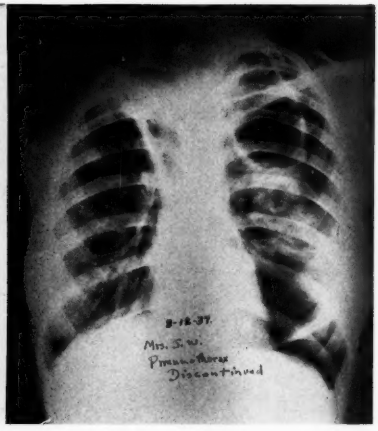


Fig. 13.

Fig. 12.—J. W. Roentgenogram made at entrance, showing huge bilateral cavitation.

Fig. 13.—J. W. Pneumothorax given on left and discontinued. A giant thin-walled cavity is shown.

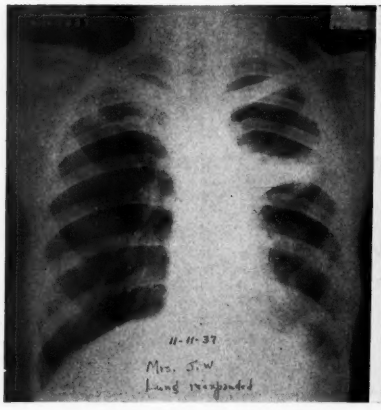


Fig. 14.

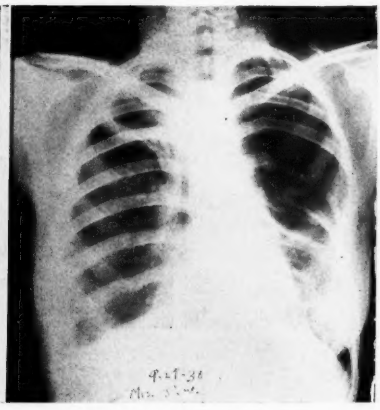


Fig. 15.

Fig. 14.—J. W. Immediately prior to operation. The lung has re-expanded and the cavity occupies the entire upper half of the left chest.

Fig. 15.—J. W. After ten months. Extrapleural pneumothorax on left side ten months postoperative. The cavity is entirely obliterated. Shortly before pneumonolysis for the cavity in right apex.

up on the opposite side at some later date, the amount of breathing space on the already operated side is of vital consequence, and in a certain percentage of those cases, it is possible to allow a partial or

more or less complete re-expansion of the lung. It has been my experience that, as late as two or three years after initiating extrapleural pneumothorax, the lung will re-expand to a greater or less extent, with the discontinuance of the pneumothorax refills. No positive statement can be made as to the degree of the re-expansion, as my observations on this point are not extensive enough nor complete enough for any conclusions. In almost all the cases of this series it has been felt that the lung should never be allowed to re-expand, and the pocket has been filled with oil. However, the tendency of the lung to fill the extrapleural space is marked, even after the lapse of several years.

Large cavities which can be compressed only inadequately by the most extensive thoracoplasty are ideal for treatment with extrapleural pneumothorax. This may be continued for any desired length of time, but, since there is no hope of ever allowing re-expansion, the space should be filled with oil to obviate indefinite continuance of the refills. Extrapleural pneumothorax is necessary, of course, as a preliminary to oleothorax. The extrapleural pocket is brought to the exact size and conformity desired to achieve compression of the diseased area with minimum loss of function of the balance of the lung, and after the results seem satisfactory, the pocket is filled with oil.

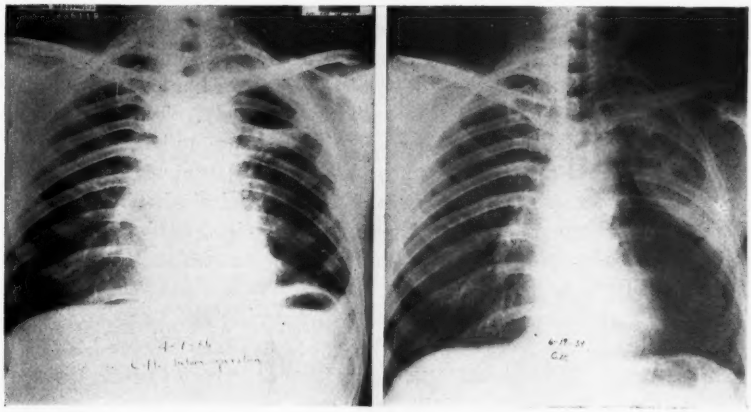


Fig. 16. Fig. 17.

Fig. 16.—C. H. Before operation. Very large cavity in left upper lung.
Fig. 17.—C. H. After extrapleural pneumothorax to obliterate cavity and three years of extrapleural oleothorax.

DISADVANTAGES OF EXTRAPLEURAL PNEUMOTHORAX

There are certain definite disadvantages which one must consider. Refills are necessary every two to four weeks for an indefinitely long period. I have never allowed a case to go more than four weeks, and I find that at the end of three to four weeks the lung is re-expanding.

This sometimes occurs quite rapidly, even after the pneumothorax has been continued two years or more. There may, of course, be exceptional cases where the interval can be increased very considerably, but in my experience this has not been advisable.

Any of the complications previously mentioned is possible, and these do present a definite check on overenthusiasm for the procedure. One must always keep them in mind in selecting and continuing this method of treatment. When the pneumothorax is discontinued, the disease may again become active. The general rule here for intrapleural pneumothorax cases has been that they be held compressed for three years with negative sputum, including frequent examinations of the sputum, before re-expansion is allowed. Even after from three to five years the sputum may become positive on re-expansion. Should such a flare-up occur after allowing re-expansion with extrapleural pneumothorax, it is highly improbable that the compression of the lung could again be increased.

ADVANTAGES OVER THORACOPLASTY

The operation presents certain definite advantages over thoracoplasty, both from the standpoint of the patient and of the surgeon, not counting those previously considered. In the first place, only one operation is necessary, which of course is always a big consideration, especially in those instances where otherwise three, four, or more operations might be necessary to attain the desired result. The cough mechanism is better because there has been less crippling of the chest wall, and there is much less pain than following the average thoracoplasty. There is no deformity produced except a lower and shorter scar, and this is of considerable moment to many of the patients. Those who are unfortunate enough to need surgical treatment for their tuberculosis should have little regard for how an improvement or cure is obtained, and yet it is surprising how the question of deformity is uppermost in the minds of many. There is less shock to the operation than to thoracoplasty. This is rather surprising, especially when considering the degree of compression that is obtained, but nevertheless, it has been observed that the patients stand this procedure better than the average five-rib thoracoplasty.

CONCLUSIONS

Extrapleural pneumothorax is a very valuable addition to thoracic surgery. Many otherwise hopeless cases are given a chance for recovery.

Oleothorax attains the goal of a permanent filling. For more than thirty years a means of permanent localized compression for the lung has been sought, and oil seems to be the ideal material. After four years' experience it appears free from complications.

Most cases of extrapleural pneumothorax where permanent collapse of the diseased area is desired should have oleothorax.

DISCUSSION

DR. FRANK S. DOLLEY, Los Angeles, Calif.—Dr. Proctor's excellent paper is particularly pertinent in connection with the many queries that still remain unsatisfactorily answered concerning the present comparative value of extrapleural pneumothorax and the eventual fate of the lung collapsed by this procedure.

I believe Dr. Proctor's series extends over a considerably longer period than any other in this country. Dr. Edwin Bennett, Medical Director of Olive View Sanatorium, seeing some of Dr. Proctor's cases more than two years ago, urged us to establish this space on certain of our patients. Because it appealed to us neither anatomically nor surgically, we deferred its trial until almost two years ago, when Dr. Jones developed our first extrapleural apical pocket. Because of its favorable outcome we have continued to employ this method of obtaining selective lung collapse. Benefited by the experience of Graf and Schmidt and their associates, we have restricted this operation to only those cases in which the indications seemed to us preferable to those for thoracoplasty. This question as to comparative indication is, of course, a fundamental one. When this seemed answered with reasonable satisfaction, we asked ourselves, and still do, concerning the eventual fate of the portion of lung collapsed. Must the introduction of air be continued throughout the remaining years of the patient's life? Will the lung re-expand when pneumothorax is discontinued; will some material be injected to replace air eventually; or will it become necessary eventually to obliterate the space by thoracoplasty and thus perform an operation after many months of expensive and somewhat hazardous delay that might have been done in the first place?

The National Tuberculosis Association asked Dr. Jones and me to prepare a comprehensive review of world-wide experiences, together with our own, regarding this procedure. The results of our study were delivered by one of us (F. S. D.) at the Boston meeting last week. We wrote to various men abroad and in this country whom we knew had had considerable experience with extrapleural pneumothorax. We got back a large percentage of personal communications, among them Dr. Proctor's. By this means we were able to compile contemporary replies that represent their respective experiences up to one or two months ago, rather than having to depend upon publications that often were one or more years old.

We asked what their indications were for extrapleural pneumothorax and what their results were after three or more years of treatment. We found we could divide them roughly into two groups. One series of men did extrapleural pneumothorax only when the patient or his pulmonary condition was desperate. The results with these cases were very poor and very discouraging, and in the end they either gave up the procedure or, at the time of writing us, were on the point of doing so. The indications were thoroughly bad, but it seemed the last expedient in the hope that the patient might be improved.

There was another group, of which many of the cases mentioned by Dr. Proctor are examples, where selection was carefully made according to the criteria just mentioned by Dr. Proctor, and by Graf, Schmidt, Adelberger, and Theiss in their publications, and more recently by us. In this group, the tuberculous lesions are comparatively well stabilized; the cavities are not stiff-walled, nor widely and intimately adherent to the chest wall from which they may be obtaining their blood supply largely, and they do not extend below the fifth interspace posteriorly.

If the condition answers satisfactorily these criteria, the operation, we feel, is indicated, provided that a limited thoracoplasty does not seem to offer a reasonable chance for cavity closure or has been definitely refused. Extrapleural

pneumothorax, in addition, is possible and offers a comparatively good prognosis after the exclusion of thoracoplasty in the extremely young and old, when stationary bilateral disease exists, and when the latter operation would require an enormous sacrifice of uninvolved lung.

Those men both abroad and in this country who have, for the most part, limited their cases to those which satisfy the indications mentioned in this second group consider the procedure much to be preferred to thoracoplasty. Their combined results show 65 per cent of the patients with sputum conversion, and without multiple rib resection or disabling reduction in vital capacity.

The eventual fate of the pneumothorax space and collapsed lung at last seems to be reasonably secure. Graf began his series in 1932, Schmidt in 1934, and Proctor in 1935. We are indebted to them for the experience they have had in late lung re-expansion. Both Graf and Adelberger, who since Schmidt's untimely death has carried on his work, are convinced that eventual conversion of air to oil is advisable and satisfactory. An overwhelming percentage of their early cases are so converted. The floor of the extrapleural space, made up of pleural leaves and collapsed lung, becomes so thickened that re-expansion seldom occurs. Air is gradually replaced by oil and, except at long intervals, is not molested. Fibrosis reduces the space by from one-third to one-half, and oil occupies the remainder. No complications are reported in these early cases. It is very interesting that, without knowledge of the conclusions of the European workers, the majority of Dr. Proctor's first cases have been converted to oleothorax. This replacement is a consistent development in the care of these patients. In our own series, we noticed that those converted to oleothorax because of tuberculous infection within the extrapleural space or because of early lung re-expansion required much less care than those receiving frequent air refills. Just as Dr. Proctor gradually changed to oil, so have we. I now believe that oil conversion should not be postponed for months, but should be accomplished within a comparatively few weeks after operation, that is, as soon as one is assured that the space is well established and that the pleural leaves are well thickened and the danger of cavity wall necrosis is past. In this way, a very large percentage of the late complications that extrapleural pneumothorax is liable to can be eliminated.

DR. GEORGE ORNSTEIN, NEW YORK, N. Y.—I wish to ask Dr. Proctor the following questions concerning extrapleural pneumoleothorax versus thoracoplasty:

1. In how many of his cases in four years did he have sputum conversion?

2. What complications had occurred and how frequently?

The puzzling thing is why one must continue therapy for many years after the sputum has been converted from positive to negative.

At Sea View Hospital we determine extrapleural pneumothorax in extensive bilateral pulmonary tuberculosis to be contraindicated because of the great loss of vital capacity after the extrapleural pneumothorax is done.

We noted over 30 per cent extension of the disease into the extrapleural space. It is our opinion that there could only very occasionally be a choice between extrapleural pneumothorax and thoracoplasty.

DR. EDWARD J. O'BRIEN, DETROIT, MICH.—I agree with Dr. Dolley that the procedure is here to stay. I think it is a question of indications. Our indications, after trial, have been limited to these:

1. In children under 14 years of age, where the disease must, of necessity, be rather soft and early, and where the deformity will be so marked following thoracoplasty, we try extrapleural pneumothorax.

2. In extensive, soft, exudative lesions, where one can expect excavation to go on under the rebridged bone following thoracoplasty, we prefer to try extrapleural pneumothorax, hoping that we can keep the lung down long enough to have partial clearing by resolution, and the remainder, after the excavation has taken place, can then be taken care of by thoracoplasty.

3. As Dr. Proctor has said, in the gutter cavities in the lower lung fields, when the rest of the lung field is relatively free from disease and where an extensive thoracoplasty would be required, collapsing mostly good lung tissue permanently, we think a trial at extrapleural pneumothorax should be made.

4. In the soft, honeycombed lesions at the apex or infraclavicular regions, we try this procedure if it is reasonable to expect healing during the length of time the lung can be held down with the extrapleural pneumothorax.

It is understood, of course, that in all of these indications, artificial pneumothorax, phrenic nerve operations, and bed rest have failed.

As to oleothorax, I will take vanilla myself. We have not had any difficulty with oleothorax in extrapleural pneumothorax because we have not used it, but we had two people drown from intrapleural oleothorax. If you remember the slides Dr. Proctor showed, you will recall that he gave, as one of the dangers and complications, the possibility of necrosis of the cavity wall. In one patient, he showed about half of both lungs excavated. In our opinion, extrapleural pneumothorax is contraindicated in such patients. If we accept Dr. Dolley's statement that the lung will not re-expand after three or four years, what is the object of toying with the patient during this time? Why not do a thoracoplasty at once?

Dr. Proctor says, and quite honestly, "We believe thoracoplasty is the better procedure, and extrapleural pneumothorax should be done only where one does not think thoracoplasty can accomplish the same result." This is a matter of personal judgment. I have seen a number of papers written on extrapleural packs of paraffin, and the reason given for the use of the procedure was that thoracoplasty could not be tolerated by the patient. How this was determined was never clear. I, personally, think you should limit extrapleural pneumothorax to the small field which I have outlined. I do not like to maintain collapse with oleothorax for a period of years because of the potential dangers of amyloidosis, pressure necrosis, etc., so if this becomes necessary to maintain collapse, I prefer re-expansion followed by thoracoplasty. It may be true that, to date, there are no reports of oil breaking through into a bronchus in an extrapleural pneumothorax, but I am sure there will be if it is continued.

DR. SAMUEL ROBINSON, SANTA BARBARA, CALIF.—It occurs to me that we are faddists, we medical men, and I am very much interested in long-range visualization of this problem. I think I have performed all of the various types of collapse therapy operations, and I have listened to these presentations with great interest. After all, a thoracoplasty without apicolysis is a tedious, uninteresting operation. If you have a number of them to do, it is rather hard work and there is nothing appealing about it. The apicolysis operations are very interesting. We are always interested in operations that are dangerous, and these are somewhat more hazardous than routine thoracoplasties. Furthermore, I think that we are inclined to think apicolysis is a less treacherous operation to the patient than first-stage thoracoplasty. I rather doubt this. It is not at all difficult to use up an hour, or even more, in a careful extrapleural or extrafascial dissection.

My prophecy is that, although we are trying this new type of operation on the apex, we are going to swing back toward thoracoplasty again, and that our selection of cases for the apicolysis process is going to be small and in rather a limited

field. Inasmuch as the chief reason for doing apicolyses is that we have so often seen cavities in the apex persisting despite thoracoplasties, Dr. O'Brien will probably say that if one did the first-stage thoracoplasty properly, he would not have so many of these pictures illustrating persistent cavities at the apex. Perhaps we shall learn more about the first stage, or shall do it better, or do it as he obviously does it, with much success, particularly with his very low percentage of persisting cavities after it.

I am glad Dr. Proctor described some of the complications of the extrapleural type of procedure. After all, five years is not very long in which to learn just exactly what an operation means. I think there will be many complications following this. I had the extraordinary experience recently of doing what appeared to be my hitherto most successful extrapleural separation. The apex was well down and looked as though it must stay there, regardless of what was done afterward. One of my associates, who was accustomed to carry on with the injections after these operations, reported in a few days, I think about the fifth day, that he was not able to get air in as he had been at the first injection after the operation. We took pictures and found the apex was very high. We again tried to force it down with air and accomplished nothing. On the eighth day I reoperated upon the patient and did exactly the same operation as I had done in the first place. To my great surprise, it was just as difficult to dissect the fascia away from the parietal pleura as it had been in the first operation. I was appalled at the firmness of the adhesions which had recurred within seven or eight days. I did that dissection again in exactly the same way and produced an equally complete release. This time, through an intercostal puncture, I inserted a very small rubber catheter, and while the wound was still open from the resection, I placed the tip at the top of the space. I did not stitch it there. We learned a few things after that operation. We learned how quickly more air was needed. We have a habit of doing it every two or three days. Every day was not too much to maintain a proper record on the manometer. While using the catheter, I found that, if the pressure exceeded a certain point, emphysema developed. In other words, the air was forced out through the original intercostal wound into the tissues. That patient developed fluid and, ultimately, empyema. That only shows how much will come out in connection with the extrapleural and the extrafascial procedures when we all report all of our cases and all of our difficulties. After all, in thoracoplasty, when you are through, you are through. When you have successfully done the three stages, you are through.

One other illustration. When we talk about extrapleural or extrafascial, I am not sure you will concede that at times we wander from one to the other in our dissections. We may start extrapleural. I thought I was progressing successfully in an extrapleural dissection, when to my great surprise, I suddenly opened a lung cavity. This was distressing. I curetted it superficially and feared it would bleed, which it did not, and then I inverted the edges and went on with my dissection, obtaining a very good collapse. I put a rubber tube into the space. Infection resulted. Repeated efforts to find the tubercle bacilli failed, and that man today has a complete collapse. After the tube was removed, the chest was aspirated a number of times, and his space is apparently obliterated; but he now has tubercular infection of chest wall tissues.

I cite these illustrations of the difficulties that we are confronted with in these apical operations, and I again prophesy that, after our enthusiasm to do something more interesting and new has subsided, we will drift back into a greater enthusiasm for thoracoplasty, with or without partial apicolysis.

DR. V. S. RANDOLPH, PHOENIX, ARIZ.—I want to ask Dr. Proctor, if he can, to say more about complications in the extrapleural space. I had a case of a man who had an extensive disease of the right lung and also a cavity in the left. Although the case was not suitable for extrapleural pneumothorax, nevertheless, because of the conditions, I did an extrapleural separation on the "bad" side. There was rather a large extrapleural space as low as the seventh rib, and I had to maintain high pressure, over +50. About four or five months after this was done, he developed an air pocket beneath the scapula. It did not leak elsewhere. He has kept that air pocket right at that particular place. It communicates freely with the extrapleural space. After a refill, the subscapular air pocket becomes hard, and before the refill it is soft. I am just wondering what is going to happen. It has not hurt his pulmonary collapse, and his symptoms are very well controlled.

DR. OSCAR S. PROCTOR.—I am very thankful for the discussion. A great many things were not included, I admit that. In twenty minutes one can cover only some of them. I had to hurry more than I wished in order to get through. Dr. Aycock mentioned extrapleural air several times. I did not say anything at the time, but I think a more appropriate and apt term would be extracostal air in order to avoid confusion with extrapleural pneumothorax.

Dr. Eloesser asked me what kind of oil. That is one of the numerous points I could not cover. I think one could use either mineral oil or olive oil. I prefer olive oil because I do not like any paraffin or mineral oil in the tissues. Our experience is confined to olive oil, with from 2 to 5 per cent gomenol.

I do not know just how to answer Dr. Ornstein. I tried to show as illustrations some of the types of cases which we felt could not be handled very successfully by thoracoplasty. Giant cavities, usually after a very extensive thoracoplasty, including the transverse processes and the costal cartilages, often leave a slitlike or narrow residual cavity, with positive sputum. We feel that where thoracoplasty will accomplish the same results, it should be used, of course. It is simpler and better. There are many cases, in our experience, where thoracoplasty will not accomplish the same result. In addition, in a great many instances, there is much less destruction of good lung with extrapleural pneumothorax than with any kind of thoracoplasty. He mentions the oil and getting anaerobic bacteria from under the oil. I do not know just how that is done. We put oil in a dry cavity, and the oil stays at the bottom and we have no bacteria of any kind. The cavity is filled with oil.

I never tried vanilla. I will have to find out from Dr. O'Brien where he gets it and what strength. I can tell him the oil sets up considerable reaction in the walls of the extrapleural space. One can tell readily within a week after putting in oil that it has been injected because the walls of the space are thickened; there is more resistance to the needle, and the thickness of the space protects the patient against drowning in oil. I do not think any of our cases will drown in oil, Dr. O'Brien. The wall is really quite thick. Necrosis will not occur from the weight of the oil. That is one thing about paraffin. Of course, the paraffin will often necrose through the cavity wall into the cavity. We have several cases in which the oil has been in the extrapleural space for four years; no such thing has taken place, and I am very confident it will not.

Speaking of allowing the re-expansion of large cavities, such as the one case I showed, of course we do not contemplate ever allowing them to re-expand. We fill the space with oil. We accomplish less destruction of what good lung the patient has left than we would by thoracoplasty.

Dr. Robinson mentioned complications. We do have complications. One complication has been the tuberculous empyema. We have found that, in this extra-

pleural space, it is not so severe as intrapleural empyema. Wash the cavity out through a needle with salt solution and get it mechanically clean. The temperature rapidly becomes normal, and the patient has no more trouble from that source. As rapidly as we can, we fill the space with oil. In a number of instances, we have been able to institute oleothorax.

As regards putting in a catheter. That never occurred to me at any time, because, naturally, a catheter left in this space will cause infection. When Graf first started doing this work in Germany, he left a catheter in. The infection goes through where the catheter is. In that connection, we feel definitely that the surgeon or some one who has been present at the operation should give the air; otherwise, the lung may be punctured, and one will run into many complications which are avoidable.

Dr. Robinson also mentioned that this enthusiasm will wear off and that we will go back to the limited thoracoplasty. I am sorry he did not get the point that I tried to put over, and that is that I did not come out in any burst of enthusiasm, although I have been using this procedure for four years. I wanted to wait until I knew something about it before rushing into print. I feel the procedure is definitely here to stay. Thank you very much.

THE DIAGNOSIS AND SURGICAL THERAPY OF PATENT DUCTUS ARTERIOSUS

JOHN C. JONES, M.D., FRANK S. DOLLEY, M.D., AND (BY INVITATION) LEWIS T. BULLOCK, M.D.,
LOS ANGELES, CALIF.

IN 1907 Munro[1] advocated the ligation of patent ductus arteriosus. His suggestion, however, was not taken as seriously as he had hoped. In May, 1938, Graybiel, Strieder, and Boyer[2] reported an unsuccessful attempt to ligate the ductus in a patient with subacute bacterial endarteritis. Not until August, 1938, was the first successful ligation performed by Gross and Hubbard.[3] We will report the findings and immediate results on seven operated cases. Six of these patients are from the cardiac clinic of the Children's Hospital, and the last is from the Los Angeles County Hospital.

The ages of the patients were from 4 to 31 years (Table I), and three were males and four, females. They were born at term, except the second patient who was born at 7½ months; development in infancy was normal.

All except the youngest had had the common diseases of childhood. None had had rheumatic fever or chorea. The first case had undescended testicles and webbing between the toes. There were no other apparent associated developmental defects. The fourth case had a spastic paralysis of the arms from a birth injury, and the last had a lung abscess at 13 years. There was no family history of heart disease or congenital defects.

None of these cases was cyanotic. In only the first was there a history of transient cyanosis on one day, two years before, at the time of a severe cough due to acute bronchitis. None of the cases had had congestive heart failure or edema. A heart lesion was discovered early in infancy in four patients, at the age of 4 in two, and at 5 years in the other one.

The 4-year-old child had had no cardiac symptoms. The enlarged heart and murmur were found when she came to the clinic for a tonsillectomy. The others had been on a restricted regime, avoiding strenuous activity. They were comfortable at rest but complained of weakness, ease of fatigue, or dyspnea on exertion. The third case had one fainting attack a week before admission, and the last had frequent sudden attacks of tachycardia and dyspnea over a period of seven years.

Except for the well-nourished 4-year-old child, they were all rather slim, though none remarkably so. Pallor was not striking in any one, and none showed cyanosis, clubbing, or edema.

Read before the Twenty-Second Annual Meeting of the American Association for Thoracic Surgery at Los Angeles, Calif., July 5, 6, and 7, 1939.

TABLE I

CASE	1	2	3	4	5	6	7
Age (yr.)	13	13	13	11½	4	6½	31
Sex	M	M	F	F	F	M	F
Murmur discovered	5 yr.	7 mo.	Birth	16 mo.	4 yr.	4 yr.	Birth
Fatigue	+	+	+	+	0	+	+
Dyspnea	+	0	+	0	0	+	+
B.P. at rest	136/0	135/50-20	135/50-25	105/65	120/40-0	125/50-0	125/80
B.P. during anesthesia	180/0	140/50	180/0	130/35	120/0	120/0	160/120
B.P. after ligation	152/90	150/90	180/80	135/60	120/75	120/65	150/140
B.P. on discharge	130/70	130/75	125/75	115/75	120/75	105/70	130/75
Thrill Ics	2nd	3rd	2nd	0	2nd	2nd	2nd
Increased P_2	Obscured	Obscured	+	+	+	+	Obscured
Murmur	Loud rough	Loud roar	Loud rough	Slightly rough	Loud roar	Soft blow	Moderately loud
Murmur maximum Ics	2nd	3rd	2nd	1st	2nd	2nd	2nd
Accentuated	D	Late S and early D	D	Late S and early D	Late S and early D	Late S and early D	S
D at apex	+	+	+	0	+	0	0
Q_3	+	+	+	+	0	+	0
Notch R_1	+	0	+	0	0	0	0
Depressed $S\text{-}T_{2,3}$	0	+	0	+	+	0	0
Date of operation	3/28/39	4/27	5/6	5/15	6/8	6/17	6/29/39
Complications	None	Vocal cord paralysis	Late death	None	None	None	None
Murmur on discharge	Soft S	Soft S	Soft S	None	None	None	Moderate S

Ics, intercostal space; P_2, pulmonary second sound; D, diastolic; and S, systolic. Q, R, and S-T refer to waves in the electrocardiogram in respective leads.

All except the adult showed a high pulse pressure with low diastolic blood pressure. The diastolic pressure was often difficult to measure exactly, there being no sharp point which could be read with certainty. It also varied markedly with activity and under varying conditions. The first case, even at rest, had a classical Corrigan pulse and pistol-shot sound over the femoral artery (Fig. 1). In the sixth case these signs appeared only after exercise. As pointed out by Bohn,[4] exercise caused a marked increase in pulse pressure with a drop of the diastolic pressure, often to zero. Even excitement tended to cause a lowering of the diastolic pressure. Induction of anesthesia tended to cause a lowering of the diastolic and, at times, a rise in the systolic pressure. The third case had a pressure of 135/50-25 mm. of Hg before, and 180/0 after, induction of anesthesia. In the adult, however, both exercise and anesthesia caused a rise of systolic and diastolic pressures. In every case, pulsation was palpable in the femoral artery, and the blood pressure was higher in the leg than in the arm. These findings were used to exclude coaretation of the aorta.

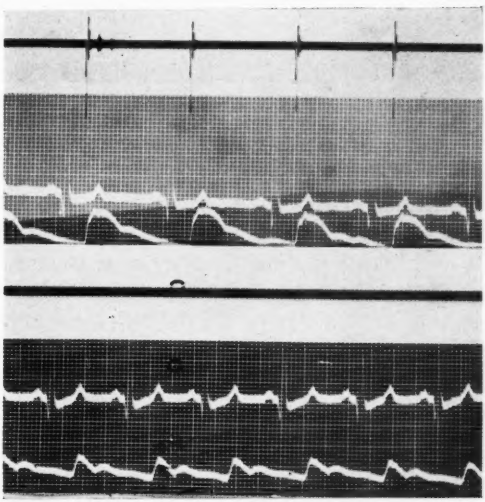
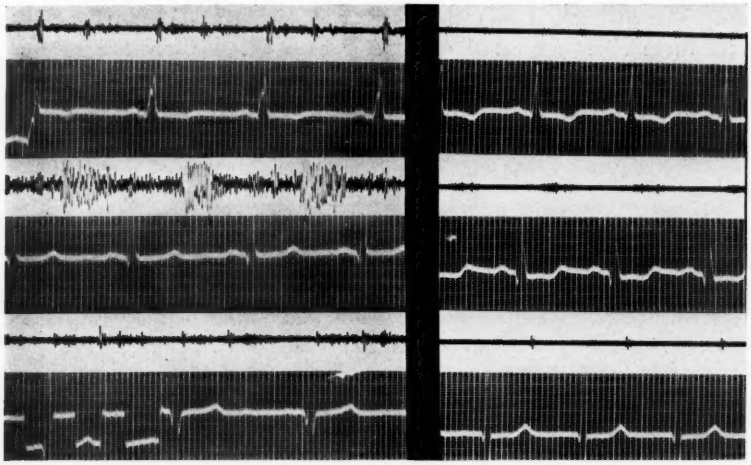


Fig. 1.—Case 1. The upper tracing, made before operation, and the lower one, after operation, show Lead II of electrocardiogram. Pulse tracings from the wrist show change in form and amplitude following operation. The sound track shows the pistol-shot sound over the brachial artery which disappeared after operation.

A precordial heave was visible in the first three cases, and a thrill was present in all except one. In five cases the thrill was maximum in the second left intercostal space, and in the other it was maximum in the third interspace. The thrill was apparently systolic in time in one case, and in the other five it extended into and was maximum in the diastole. The timing of the thrill required considerable care and

was checked with electrical records of the murmur. The first sound at the apex was uniformly normal. The pulmonic second sound was increased in four cases, and in three it could not be distinguished from the murmur.



A. *B.*

Fig. 2.—Case 1. *A*, Before operation; *B*, after operation. From top to bottom are given Leads I, II, and III of the electrocardiogram. In the same order, the sound tracks are from apical, pulmonic, and aortic areas. A continuous murmur is present in all areas. In the pulmonic area, it is accentuated in diastole. After operation, a purely systolic murmur, which is barely detectable at the apex, remains at the pulmonic area.

There was a continuous murmur in the pulmonic area in all cases (Fig. 2). This varied from a soft blowing hum, through a slightly rough murmur, to a loud rough roaring murmur. This was accentuated in systole in one case, in late systole and early diastole in four, and in diastole in the other two. The timing of this accentuation was difficult. Some errors were made in favor of systolic accentuation which were corrected after electrical recording of the murmur. Such records were made in all except the last case. The murmur was maximum in the first left intercostal space in one case, in the third interspace in one case, and in the second interspace in the others. The systolic element of the murmur was transmitted to the apex in all except the last case. The diastolic murmur was definitely audible at the apex in four instances, and in two had previously led to a diagnosis of mitral stenosis. The systolic element of the murmur was audible in the neck in all patients and was heard in the back between the scapulae in all but the last. The continuous murmur was faintly audible in the aortic area in every case, except in the last in which only the systolic element was heard in this location.

The urine examination and the Wassermann test were negative, and the complete blood count was within normal limits in all patients. With the exception of the fourth case, enlargement of the heart was uniformly demonstrated by two meter posteroanterior and oblique roentgenograms. The pulmonary conus was from slightly to markedly increased in size in each case (Fig. 3). The electrocardiogram showed no axis deviation, except in the fourth case which exhibited a slight right axis deviation. The Q wave in Lead III was prominent in five cases, and the R wave in Lead I was notched in two (Fig. 2). The S-T interval was slightly depressed in Leads II and III in three cases, and the T wave in Lead I was inverted in the first case. All other electrocardiographic findings were normal.

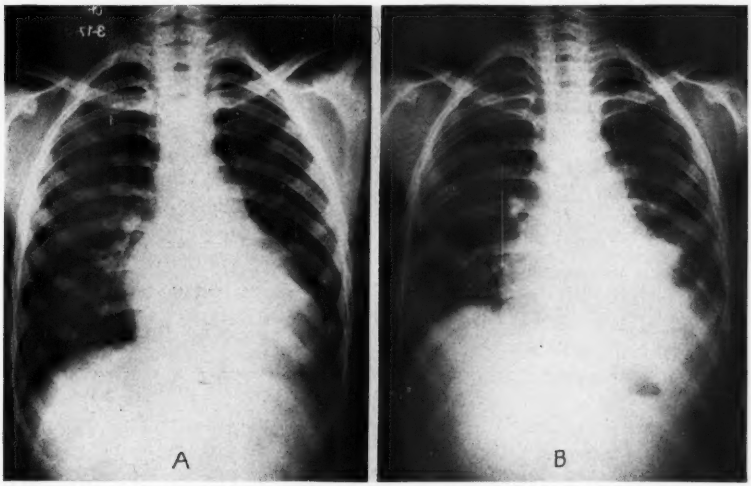


Fig. 3.—Case 1. *A*, Before operation; *B*, ten days after operation. Enlargement of the heart and prominence of the pulmonary conus are shown. The latter is less evident after operation.

In summary, these cases all had typical physical signs and laboratory evidence of patent ductus arteriosus. A continuous murmur in the pulmonic area, varying in intensity during each cardiac cycle and usually accompanied by a thrill, is the most important sign. Increase of the pulmonary second sound, prominence of the pulmonary conus on x-ray examination, absence of cyanosis, increase of pulse pressure with low diastolic pressure, and absence of axis deviation of the electrocardiogram are usually present as confirmatory findings.

OPERATIVE TECHNIQUE

We used cyclopropane and oxygen anesthesia administered through an intratracheal tube.* In all cases the anesthesia was smooth and uneventful. Nembutal,

*The skill with which Dr. Charles F. McCuskey and Dr. L. D. Lee administered the anesthetics was an important contribution to the ease and success of these operations.

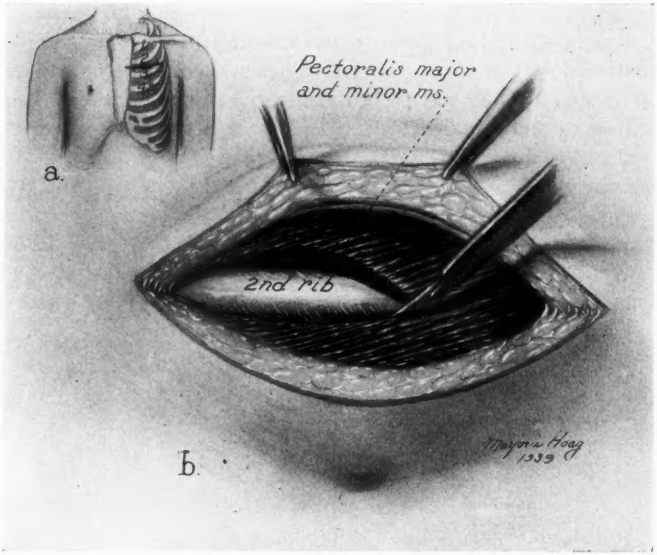


Fig. 4.—*a*, In the male a linear incision is made along the second intercostal space from the parasternal to the anterior axillary lines. In the female, a curved inframammary incision is employed.

b, The fibers of the pectoralis major muscle are split, and the pectoralis minor muscle is incised in the line of the incision.

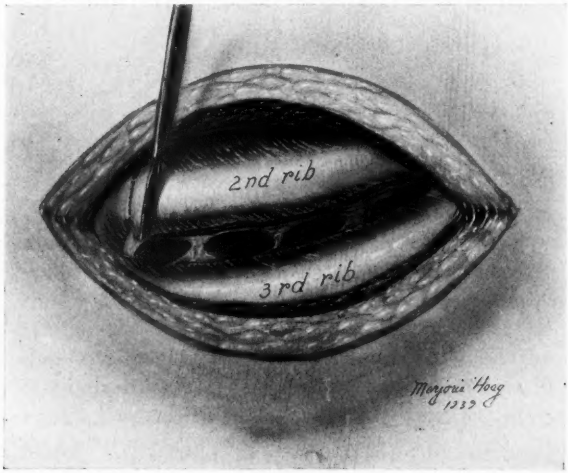


Fig. 5.—The intercostal muscles and parietal pleura of the second interspace are incised, and short segments of the second and third cartilages are excised by transection.

morphine, and scopolamine, administered preoperatively, varied in dosage with the weight and age of the person. Positive pressure was employed to re-expand the entire lung for a few seconds every ten to fifteen minutes. Gentle manual massage of the darker atelectatic areas of the lung was done at this time so that virtually all of the lung was aerated. Slight positive pressure anesthesia was likewise employed during the closure of the chest wall and wound.

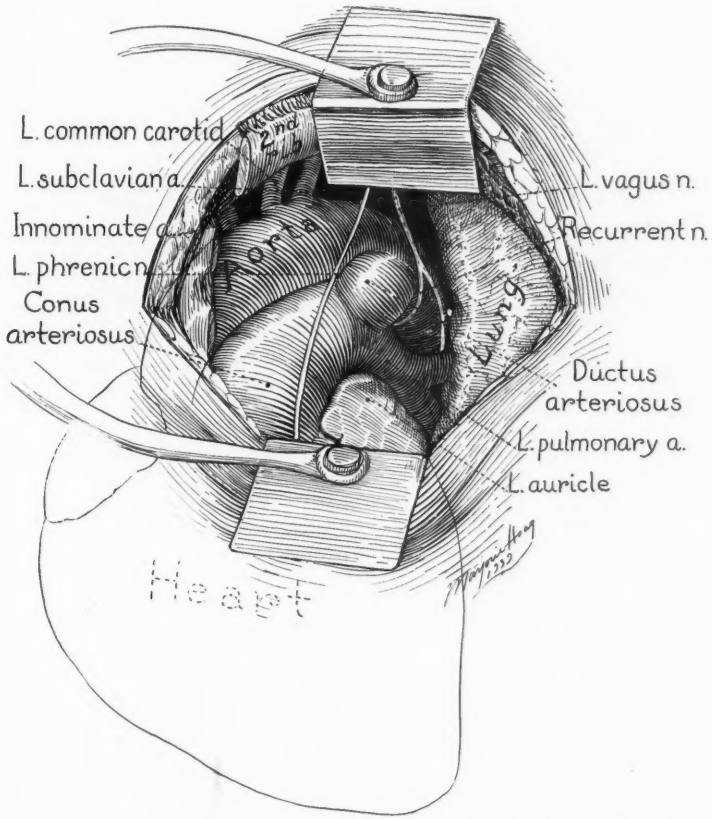


Fig. 6.—Illustration of the anatomic relation of the ductus arteriosus to the surrounding structures.

Two different incisions were employed in these operations. In males, a linear incision along the second intercostal space from the parasternal to the anterior axillary lines provided a practical approach to the field of operation (Fig. 4). The fibers of the pectoralis major muscle were split for the most part, and the pectoralis minor muscle was incised in the line of the skin incision. In the female, an inframammary incision beginning at the third costal cartilage, circling beneath the breast and upward to the anterior or midaxilla at about the fourth rib, was utilized for cosmetic reasons. The pectoralis muscle was incised in the line of the skin incision and reflected upward with the breast. This latter incision also allowed a safe and adequate exposure.

The intercostal muscles of the second interspace and the parietal pleura were incised, midway between the ribs, from the costal cartilages to the anterior axillary line (Fig. 5). Then 5 mm. of the second and third cartilages were excised by transection just mesial to the costochondral junction. The intercostal vessels were doubly ligated and divided between sutures, and the self-retaining Sauerbruch rib retractor was placed and spread (Fig. 6). The collapse of the lung exposed a prominent pulmonary conus, and on palpation over this area a powerful thrill was felt. This was usually maximum over the pulmonary end of the ductus, but was well transmitted to the aorta and pulmonary artery. The phrenic nerve, as it coursed over the pericardium, was likewise prominent.

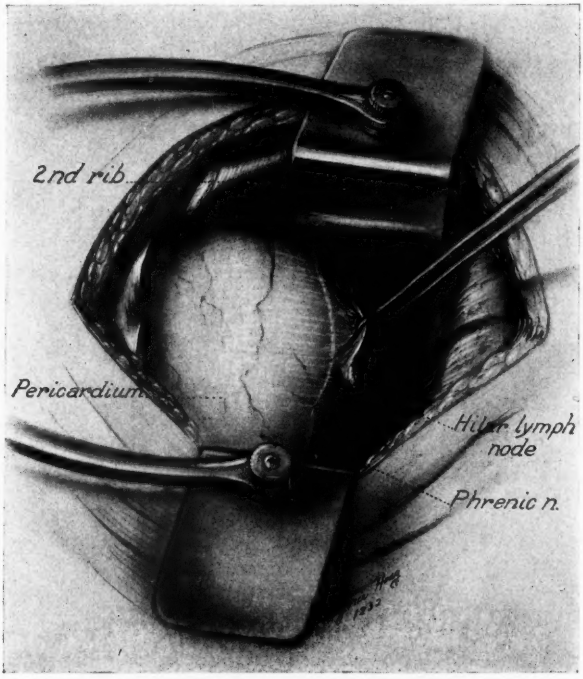


Fig. 7.—The mediastinal pleura is gently grasped and incised about 1 cm. behind the left phrenic nerve and from 1 to 2 cm. below the aortic arch, directly over the ductus arteriosus.

The mediastinal pleura was gently grasped with smooth forceps (Fig. 7) and incised 1 cm. behind the left phrenic nerve and 1 or 2 cm. below the arch of the aorta. This incision was carried upward to the aorta and downward to the left pulmonary artery. Between these two structures the ductus arteriosus and the left recurrent laryngeal nerve, looping around the ductus from beneath, were readily identified. The anterior flap of mediastinal pleura, along with the phrenic nerve, was retracted forward and medially.

The dissection of the ductus arteriosus was begun only after the recurrent laryngeal nerve and left pulmonary artery were clearly identified. After careful and complete dissection of the ductus, a blunt aneurysm needle was passed around it from below upwards. Then the needle was threaded with two No. 8 Deknatel silk sutures, and withdrawn (Fig. 8). (See addendum.)

The ductus was about 1.5 cm. in diameter in all, except in the 4-year-old patient in whom it was 1.0 cm., and the adult in whom it was 2.0 cm. We were unable to correlate the size of the ductus with the severity of the clinical signs or symptoms. In every case, the ductus was very short, from 0.5 to 0.8 cm. in length. The great diameter of the ductus arteriosus in proportion to its length precluded division after ligation.

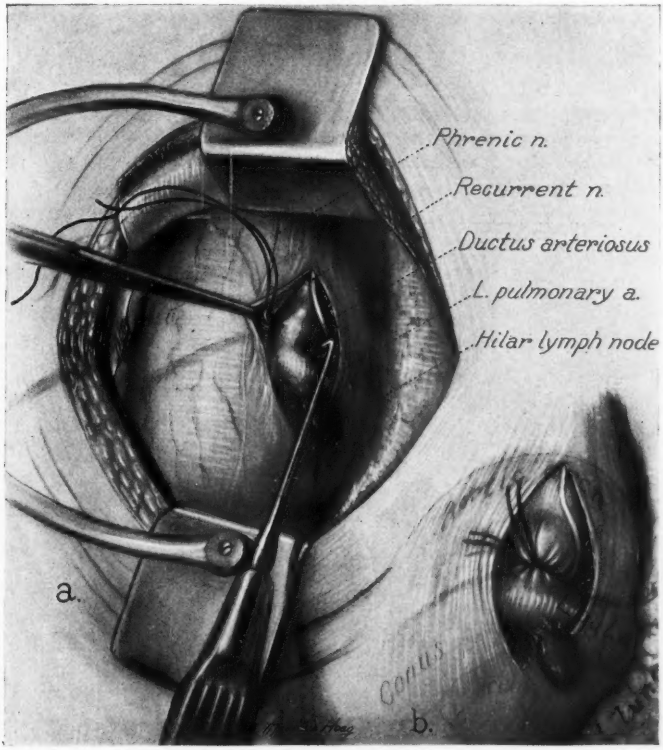


Fig. 8.—*a*, After dissection of the ductus, a blunt aneurysm needle is passed from below, threaded with two No. 8 silk sutures, and withdrawn.
b, The ligatures are tied off permanently after careful retraction of the recurrent laryngeal nerve.

The ligatures were temporarily tightened until pulse pressure tracings and careful blood pressure readings were recorded. In no case were there untoward findings to preclude the permanent ligation of the ductus, and in all cases the immediate disappearance of the thrill and the marked rise of the diastolic pressure were most dramatic. The ductus arteriosus was then ligated permanently after careful retraction of the recurrent laryngeal nerve. Then we again demonstrated the rise of the diastolic pressure and disappearance of the thrill to make certain the complete occlusion of the lumen of the ductus. After ligation of the ductus, the pulmonary artery closely approximated the aorta, since the diameter of the ductus was greater than its length (Fig. 8*b*).

One of the most important problems in this operation is the choice of material for, and the detailed method of tying, the ligature. Reid[5] has summarized and

amplified the principles involved in the ligation of large arteries. Ballance and Edmunds[6] and Halsted[7] made fundamental contributions to this problem. The ligatures must be of sufficient size in relation to the size of the ductus to avoid cutting through the wall of the vessel. They must be drawn sufficiently tight to approximate the intimal surfaces and not tight enough to fracture the intimal or medial coats. Incomplete or partial occlusion is as dangerous and as likely to lead to hemorrhage or re-establishment of the full lumen as a crushing ligature. The ligatures must be nonabsorbable, and yet they must not produce enough surrounding fibrosis to involve the recurrent laryngeal nerve in the scar. Because of its short length, it is impossible to empty the ductus before tying or to divide it after tying. Neglect of these principles may lead to rupture of the vessel with hemorrhage, or to the establishment of a false lumen around the ligature. One hopes to produce a conversion of the necrosed wall of the ductus under the ties into fibrous tissue; we do not feel that the ideal material for this purpose has yet been determined. (See addendum.)

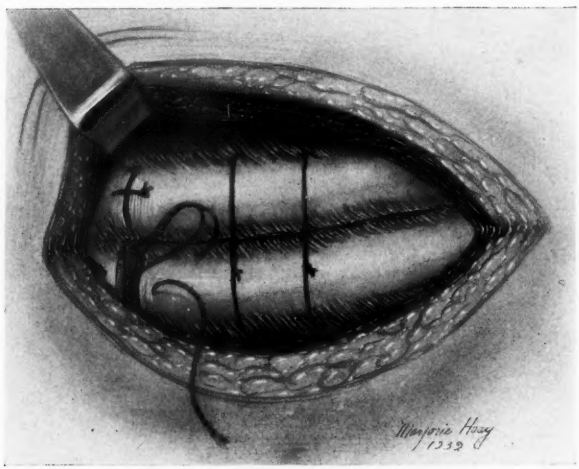


Fig. 9.—Chest wall closure is accomplished by two pericostal sutures, and the cartilages are approximated with single sutures. The soft tissues are then closed in layers.

In order to allow serous drainage from the mediastinum, the pleura of this structure was not closed. After aspiration of all fluid from the pleural cavity and expansion of the lung with positive pressure, the wound was closed without drainage. The second and third cartilages were reapproximated by single No. 2 chromic sutures, and then two or three doubled No. 2 chromic pericostal sutures were placed (Fig. 9). The intercostal bundle was closed, in some instances, with either running or interrupted catgut No. 1 chromic sutures. The pectoralis minor and major muscles were approximated by figure-of-eight sutures of No. 1 or No. 0 chromic catgut. Interrupted sutures of single No. 0 or No. 00 chromic catgut were buried in the subcutaneous tissue and fascia. The skin was closed with silk, all available air was aspirated from the pleural cavity, and the dressing was applied.

OPERATIVE AND POSTOPERATIVE COURSE

A patent ductus was found and ligated in all cases. In no case was there any evidence of coarctation of the aorta or any other complicating congenital

lesion. In the second case, a tear 2 mm. in length at the junction of the ductus and aorta was made while dissecting the ductus. This tear was occluded by a muscle transplant, and held by the ligatures around the ductus, and it caused no further trouble. Otherwise, the operative course of all was smooth and entirely uneventful. The exposure of the operative field in the 4-year-old patient was entirely adequate, no technical difficulties were encountered, and her operative and postoperative course was the calmest of all the patients.

Since all cases were in exceedingly good postoperative condition, and since blood loss was minimum, none received transfusions. As Holman[8, 9] has pointed out, the obliteration of such an arteriovenous fistula causes an automatic increase in blood volume in the arterial tree. This is indicated by the rise in blood pressure. Some caution, therefore, should be used in further increasing blood volume with intravenous fluids. Liquids were begun by mouth four to six hours after operation. The patients were given carbon dioxide inhalations and turned from side to side every three hours. Since pain was not a great factor, very little morphine or sedative was required.

The maximum temperature the day following operation was 103° F., by rectum, and this returned to normal in from three to thirteen days. All cases showed some evidence of pleural effusion on physical or x-ray examination. Two hundred cubic centimeters or less of serosanguineous fluid were aspirated from three patients. In all, the postoperative course was very smooth, with remarkably little distress or discomfort. The wounds healed per primam without infection. In all cases, the thrill and the accentuated pulmonary second sound disappeared. In four cases, a soft, purely systolic murmur remained at the pulmonic area, and in three, the murmur completely disappeared. The elevation of the diastolic pressure lasted for from three to eleven days and always returned to the normal of 70 or 75 mm. of Hg.

In the second case, a huskiness of the voice was first noticed a week after the operation. Examination showed a paralysis of the left vocal cord. The voice was still husky at the last examination six weeks after operation. The third case had an entirely uneventful convalescence and was discharged on the fourteenth day in good condition. She returned to normal activity and apparently was entirely well until thirty days after operation when she developed a fever of 105° F. and a pain between the scapulae. She was readmitted three days later, and it was found that a continuous humming murmur in the pulmonic area had returned, with systolic accentuation. Blood pressure was 115/40, having been 125/75 on discharge. Three blood cultures showed hemolytic *Staphylococcus aureus*. Roentgenograms showed a mass in the area of the pulmonary conus which had not been present twenty days before (Fig. 10). Despite treatment with sulfapyridine and hyperimmune rabbit serum prepared with bacteria cultured from her blood, the high spiking fever continued. She developed anemia, evidence of pulmonary emboli, increase in size of the mass near the pulmonary conus, and further increase in pulse pressure (110/20). She died suddenly forty-eight days after operation.

Post-mortem examination was done by Dr. George Hummer. The specimen and microscopic material were later studied by Dr. John W. Budd. The heart was definitely enlarged, but was not weighed as the heart and lungs were preserved intact for museum purposes. Both ventricles were hypertrophied, the left being 1.1 cm. thick at the apex, 1.8 cm. in the center, and 1.5 cm. at the base. The right ventricle was 0.5 cm. thick. The depth of the left ventricle was 6.0 cm. and the right 8.0 cm. The valves were all normal; the aortic ring measured 4.4 cm., the pulmonary 4.9 cm., the mitral 6.0 cm., and the tricuspid 8.0 cm. The

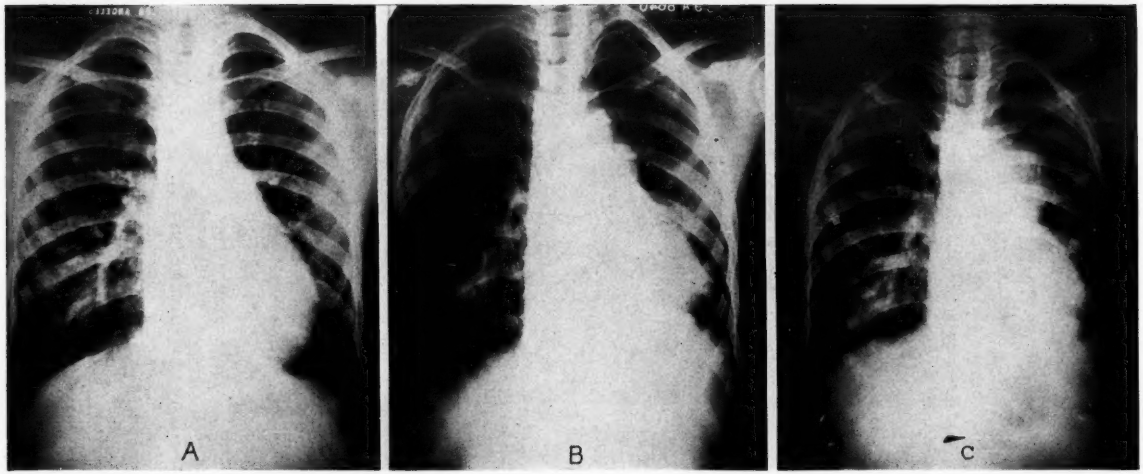


Fig. 10.—Case 3. *A*, Before operation; *B*, fourteen days after operation; *C*, forty-three days after operation. There is a slight prominence of the pulmonary conus before operation. This did not disappear after operation. The x-ray in *C* was taken just before death and shows a large mass in this area, proved to be a false aneurysm of the ductus arteriosus.

foramen ovale was closed, and except for the ductus arteriosus, there were no congenital defects. One centimeter above the aortic valve, the aorta was 5.0 cm. in circumference; just proximal to the left subclavian, it was 3.5 cm.; immediately beyond the subclavian, it was 3.3 cm.; at the ductus, 3.9 cm.; 2.5 cm. below the ductus, it was 3.8 cm.; and 5 cm. below the ductus, the aorta was 3.5 cm. in circumference. The pulmonary artery was 5.0 cm. in circumference throughout the 2.5 cm. between the pulmonary valve and the ductus.

Between the aorta and pulmonary artery in the position of the ductus arteriosus was a rounded mass 3.0 cm. in diameter, bulging toward the sternum, and posteriorly a mass 1.0 cm. in diameter protruded toward the spine. There was a dimple in the aorta at the opening of the ductus; this was 0.6 cm. in diameter, 0.3 cm. deep, and was filled by a thrombus, the surface of which was flush with the intima of the aorta. A thrombus 2.0 cm. in diameter and 1.4 cm. long extended from the ductus into the lumen of the pulmonary artery. This orifice was surrounded by friable, gray, warty vegetations which were adherent to the intimal surface and seemed to split away and elevate the inner layer of the wall. A probe could be passed without pressure through the bulging mass from the aortic dimple to the pulmonary artery.

The mass was bounded anteriorly by a thin layer of pleura and pericardium, while posteriorly the pleura was thick and fibrous. The mass was largely filled with friable, gray, laminated thrombus, in the center of which were the two black silk sutures, still tied firmly in a ring of 0.5 cm. diameter. The wall of the ductus was intact for a distance of 0.3 cm. from the aorta but gave way abruptly, and reactionary connective tissue of the thickened pleura and pericardium formed the barrier of the aneurysm thus formed. No ductus remained on the pulmonary side. Its orifice, as well as the adjacent pulmonary artery, was destroyed by vegetations.

There were numerous recent infarcts in both lungs. An embolus 0.5 cm. in diameter was found in a branch of the right pulmonary artery, but there were no peripheral emboli. The peritracheal and periaortic lymph nodes were enlarged, some to 2.5 cm. in diameter. The spleen was moderately enlarged, soft, and friable. All other organs were normal, and there was no evidence of localized infection outside of the ductus. The brain was not examined.

Microscopic examination of sections taken through the stub of the ductus showed marked thickening from adventitial and subintimal fibrosis. The medial wall was intact in places, but elsewhere there were plaquelike areas of an infarct type of necrosis. The vessel wall at the margin of necrosis was entirely deficient. The barrier of the blood channel was formed by a band of very dense fibrous connective tissue infiltrated by inflammatory cells and covered over the inner surface by a narrow lining of dense hyalinized fibrin. This barrier of reactionary tissue was continuous with the pleura and pericardium. Sections through other parts of the aneurysm wall showed the same structure of compact, cellular, fibrous connective tissue, densely infiltrated by inflammatory cells, with an inner membrane of hyalinized fibrin, which was capped in places by a zone of closely packed polymorphonuclears. Sections of the blood clot in the aneurysm showed lamellae of structureless eosinophilic hyaline material, with myriad colonies of staphylococci. The media of the pulmonary artery at the ductus orifice was eosinophilic hyaline, and not for some distance beyond this juncture was the wall intact. The intima had been split away from the media by accumulations of hyalinized fibrin, and near the orifice ragged papillated masses of blood clot and many colonies of staphylococci covered the intimal surface.

The pathogenesis of this lesion involves sloughing of the wall of the ductus, re-establishment of the connection between the aorta and pulmonary artery by

a blood channel bounded by pleura and pericardium, and infection by staphylococci. The normal temperature after operation makes it seem unlikely that the endarteritis was present at the time of the operation. It could not be definitely established whether the original injury to the wall of the ductus and the beginning of the aneurysm were mechanical from the sutures, with accidental secondary infection, or whether a primary bacterial endarteritis caused a mycotic aneurysm. Either could explain the aneurysm although only the latter could alone explain all the findings. This case, however, emphasizes the importance of the application of the principles for the ligation of the large arteries which were emphasized by Reid.[5]

One patient is still in the hospital and is doing well on the eighth postoperative day. All of the others have returned home and apparently are entirely normal.

SUMMARY

The clinical findings and the immediate postoperative results in seven patients with patent ductus arteriosus surgically ligated have been presented.

The operation has been described, and certain points in technique have been emphasized.

These and other cases must be followed over a long period before this procedure can be evaluated adequately.

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ADDENDUM

Since the presentation of this paper, we have successfully ligated the patent ductus arteriosus in six additional patients, bringing our total number of patients to date (April 10, 1940) to thirteen. Eleven of these cases are included in a report in the *Journal of Pediatrics* for December, 1939. The hoarseness of Case 2 has entirely disappeared, but hoarseness is still present, though decreasing, in one recent case. Case 7 has gone through an operation for a ruptured ectopic pregnancy without difficulty. All of the remaining cases are entirely well and have returned to normal activity.

We attempted to demonstrate the open ductus in one patient before operation without success. It seems clear, from experimental work on this subject, that this method is impractical for this purpose.

The technique of the operation has remained essentially the same, with one exception. In the last five operations we have employed a finely woven silk umbilical tape ($\frac{5}{32}$ inch wide) to ligate the ductus. We feel that the danger of damage to the coats of the ductus is definitely less with this tape than with ordinary silk ligatures.

DISCUSSION

DR. FRANK S. DOLLEY, Los Angeles, Calif.—For more than a year before Gross and Hubbard reported their first successful case, Dr. Bullock and Dr. Jones had been trying unsuccessfully to obtain parental consent for duct ligation. It was only when Dr. Bullock confronted these parents with the convincing argument of Gross and Hubbard's success that permission was obtained. Dr. Jones promptly ligated the duct of the first patient of our series. Supported by the ocular evidence of this child's recovery, parents of other children, long withheld by untried medical theory, readily consented to proved surgical fact.

We have no preoperative criteria at present as to what the comparative size of the duct may be. In one it was definitely smaller than the arch; in two, it was just about the same size; and in another, it was actually larger. The question arises, therefore, as to how much cardiac reserve there must be to permit sudden closure of the duct without assuming the hazard of cardiac failure.

In one of our cases, cardiac effort was so great during the first few postoperative days that not only the thorax itself, but the mattress and even the bed, shook under the tremendous pulsation. Particularly in adults, we feel that the probable capability of cardiac response must be considered before advising ligation.

The identification of the various structures in the region of the duct is not always simple, especially in one's first case. The duct, instead of lying free as a fibrous cord, a centimeter or more in length well below the arch, so closely approximates the aortic arch that, at first examination, it can scarcely be distinguished from it. Often only a shallow slit between them suggests that the two intimately associated structures are not one. Here the determination by palpation of the point of maximum thrill greatly aids in orientation.

The left pulmonary artery lies immediately below the duct. It was frequently evident to us that this vessel might easily be mistaken for the duct if, before ligation, the pulmonary artery were not located and clearly identified.

DR. EMILE HOLMAN, San Francisco, Calif.—One can have nothing but envious admiration for these brilliant results, envious because we have all thought about doing such a thing but did not have the courage at the time. As another's courage, however, prompts us to investigate some of these cases of probable patent ductus, we should have in mind the possibilities as to the flow of blood through the ductus. As you know, in the embryo it is from the pulmonary artery to the aorta. In surveying some sixty cases recorded in literature, we found sixteen in which this direction of flow persisted in adult life, as late as 66 years of age. In this type, of course, one would expect cyanosis, but in some of them, cyanosis did not appear until a few years, a few months, or some weeks before death. Occasionally, therefore, we will encounter a patient in whom the flow is not from the aorta to the pulmonary artery, as it was in all

these seven cases of Dr. Jones, but in whom it may be from the pulmonary artery into the aortic arch. I think the hazard of ligating such a ductus is greatly increased. Dr. Dolley suggested partial ligation and subsequent complete ligation, depending upon the effect on the heart. Obviously, under these circumstances, there is a great increase in the size of the right ventricle, and there should be a very marked ventricular preponderance.

(Slide.) This, of course, is the route through which the blood flowed in these seven cases of Dr. Jones, as shown by the normal electrocardiogram. There is an absence of cyanosis. The left ventricle is greatly enlarged, as demonstrated in some of the autopsy cases. The right ventricle is very much smaller.

In previously recorded cases of patent ductus, the wall of the right ventricle was sometimes twice the thickness of the wall of the left ventricle. One can see the preponderance which the right ventricle may have over the left if the flow is from right to left, with a correspondingly greater disturbance in the physiology of the circulation.

(Slide.) One other precaution should be mentioned in connection with this probable operation upon patients who seem to be perfectly well except for the murmur and the evidence of a patent ductus. A young boy was perfectly well until 7 years of age, except for a murmur. At 7 years he became somewhat cyanotic, developed epileptic fits, and died at the age of 9. At autopsy we had this situation. The right ventricle opened directly into the aorta, together with the left ventricle. There was no opening between the right ventricle and the pulmonary artery. The only route to provide blood flow into the lungs was by way of the patent ductus. Obviously, if ligated it would have meant prompt death on the table. Remember that this boy was perfectly well until 7 years of age.

(Slide.) This represents the heart of a boy who died at the age of 4 years after approximately three years of moderate cyanosis and gradual cardiac decompensation. In this patient, there was no right ventricle. The blood flowed directly from the right to the left auricle.

(Slide.) This is another instance of the same situation. There is no communication from the right ventricle and pulmonary artery. The patent ductus is the only route whereby the blood flowed into the lungs. Of course, the patient presented a very serious picture of cardiac difficulty from the day of birth, and he lived only six months.

DR. H. BRODIE STEPHENS, San Francisco, Calif.—I must apologize for discussing this excellent presentation. Such a sterling contribution seems too fine to warrant discussion. I cannot compliment the authors too highly upon their important contribution which is truly a landmark in thoracic surgery. I am presenting this case because I believe it will be of interest to you and perhaps will add something to the discussion.

I received the opportunity to see this patient through the courtesy of Dr. Brunn, who operated upon the woman, and it was my privilege to assist him. She was a married woman, 26 years old; when she was 2, her family physician had recognized what he said was a leaky valve, and she had been put on a careful regime of exercise and diet. She remained quite well until she was 24, at which time she began to notice marked dyspnea on slight exertion, accompanied with throbbing and pounding in her chest over the region of the heart. These attacks became more severe until she experienced them while at rest. She was 26 years of age at the time of admission, and when lying recumbent, looked like

a fairly normal person. However, upon the least exertion, she became dyspneic, and besides a throbbing over the heart, she complained of a gripping pain in this region.

The important finding on physical examination was the presence of a very marked thrill over the precordium, and a machinery-like murmur could be heard in this region throughout the entire cardiac cycle. The blood pressure on several occasions showed a marked increase in pulse pressure. The x-ray pictures showed enlargement of all the chambers of the heart and some congestion in both lung fields. The electrocardiogram showed some tendency toward left axis deviation. Cyanosis was not present at any time. We felt, therefore, that this patient was a case of patent ductus arteriosus, but we did not know why her symptoms grew so severe at the age of 24. Her blood volume determination showed the very increased figure of 10,000.

This patient was operated upon, and the operation went along very smoothly. We thought we had isolated the patent ductus. When the ligature was placed around what we thought was the ductus and tightened, the thrill seemed to disappear. The blood pressure also became elevated, and the markedly increased pulse pressure approached a more normal level. The method of operation was very similar to that employed by Dr. Jones. A fascial strip was placed around what we thought was the ductus. The patient's postoperative condition was good for a few hours, and then the temperature became markedly elevated; on the second postoperative day, we removed bloody fluid from the operative wound. This grew a hemolytic *Staphylococcus aureus* on culture; and a blood culture revealed the same organism. The patient died on the third postoperative day, and the autopsy findings showed a patent ductus which was only about 5 mm. in length. It was actually too small to have been ligated. What we ligated was some fibrous tissue overlying the ductus. There was a thrombus on the side of the ductus near the pulmonary artery. This thrombus extended down into the right ventricle. We felt this was an ante-mortem thrombus and probably did not exist until after the surgical manipulation.

DR. HERBERT MAIER, New York, N. Y.—I merely wish to point out the possibility of diagnosing patent ductus arteriosus by the intravenous injection of 70 per cent diotrast, according to the method of Robb and Steinberg, for the visualization of the heart and great vessels. This method might also be of aid in the diagnosis of associated anomalies, such as coaretation of the aorta.

DR. LEWIS T. BULLOCK.—There are many problems in regard to this procedure that we have not gone into because of lack of time. One of the things that originally interested me in this subject was Dr. Holman's dogs with experimental arteriovenous fistulas which he used to show us when I was a student. I can still remember them vividly. Dr. Holman has contributed some very fundamental work to this problem, particularly in that this is an arteriovenous aneurysm and the principles involved are the same as the principles in peripheral arteriovenous aneurysm. As to one point in particular, the blood pressure does go up to some extent after ligation of the ductus. This suggests caution in the use of intravenous fluids or transfusions after operation. Several of the house staff have been rather anxious to rush in and fill the patients full of blood, but they have not lost blood through this procedure. Their postoperative condition has been good, and because of the automatic increase in blood volume in the arterial tree, which Dr. Holman has shown comes about from the ligation of arteriovenous aneurysm, we feel a certain amount of caution should be used in this regard. With the question of the differential diagnosis, normally, of course, unless there is some complicating lesion, the blood will always flow from the

aorta to the pulmonary artery. We have set up criteria for all significant complicating lesions which have been reported in the literature and attempted to rule them out. So far, we have been successful. We hope that it will be possible to continue this with certain definite differential criteria to follow. If the blood flows from the pulmonary artery to the aorta, a certain amount of cyanosis or decreased oxygen saturation should be present. The presence of coaretation of the aorta, if proximal to the duct, will cause blood to flow from the pulmonary artery to the aorta.

Before we started, we carefully considered the advisability of using intravenous dye to demonstrate the duct by x-ray. Due to the number of reactions that have been reported, however, and to the fact that we felt we could be fairly definite and clear-cut about diagnosing without this procedure, we decided it was not advisable to use it.

Attempts to measure the amount of blood flowing through the ductus by the difference in oxygen concentration between venous, aortic, and pulmonary artery blood before and after ligation have been unsatisfactory because of the high oxygen concentration of venous blood during cyclopropane anesthesia.

Dr. Jones asked me to mention that the case of the 4-year-old child was the easiest and simplest and had the smoothest postoperative course. Two of our cases have very kindly consented to come down this morning. All of the signs in these cases have completely disappeared. These children are now apparently perfectly normal. They feel well and have returned to normal activities.

OPERATION FOR DEVELOPMENT OF COLLATERAL CIRCULATION TO THE HEART

PETER HEINBECKER, M.D., AND WESLEY A. BARTON (BY INVITATION)
ST. LOUIS, MO.

INTRODUCTION

STATISTICAL reports place heart disease first among the causes of death and disability of man. At least 40 per cent of the deaths and much of the disability result from the myocardial ischemia which follows functional or occlusive narrowing of the coronary arteries. Symptomatically, this leads to dyspnea and to pain. It results in myocardial weakness, infarction, or ventricular fibrillation. The associated signs of heart failure are too well known to need repetition. Medical measures, such as rest, a more adequate nutritional supply, and vasodilator drugs, are adequate for the treatment of milder cases and the early stages of more severe cases, but ultimately they fail. The need for further therapeutic measures can be assumed.

The clinical course of occlusive vascular disease usually affords the necessary time interval needed to provide a new source of blood supply to the heart. Coronary disease, while sometimes sudden and extensive enough to cause immediate death from ventricular fibrillation or rupture, is in more than 80 per cent of the cases not immediately fatal. Progression of the occlusion is intermittent. However, in five years the degree of progression is, in a high percentage of cases, sufficient to produce death. Such evidence warrants the suggestion that the time to provide additional sources of blood supply to the heart is after a first manifestation of its deficiency from coronary artery disease. If effectively done, it should be possible to modify or eliminate the subsequent progression which almost invariably follows.

The natural progress of occlusive disease of the coronaries does not prevent the utilization of the vascular bed of the myocardium for a union with external vessels. The first narrowing is usually confined to the larger branches and the degree of occlusion tends to lessen from above down (Karsner, 1933). It is then that collateral circulation can be most effective, i.e., before the small arteries and arterioles are involved. Of importance, too, is the fact that the smaller arteries, precapillaries, and capillaries of the myocardium and of the telae arteriae adiposae on the surface of the heart increase with age when the incidence of coronary artery disease is also increased (Gross, 1921). If the occlusion of the larger arteries takes place slowly, these two changes may be sufficient in themselves to prevent appreciable cardiac

Read before the Twenty-Second Annual Meeting of the American Association for Thoracic Surgery at Los Angeles, Calif., July 5, 6, and 7, 1939.

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ischemia or infarction, but in many persons, such reparative processes are inadequate to prevent fatal myocardial ischemia. Another favorable circumstance is that the artery most frequently involved in younger persons (80 per cent or more) is the ramus descendens of the left coronary and the infarcted area corresponding to the anterior wall of the left ventricle, because this is the region most accessible to surgery.

Normally in man the myocardium receives a very small degree of collateral circulation from the pericardium via the internal mammary, the bronchial, and the diaphragmatic arteries. Perfusion experiments in this laboratory and by Beck, Tichy, and Moritz (1935) have shown that this is also true in the dog. It is felt, therefore, that an operative procedure so designed as to increase the circulation to the heart via the pericardium would, to some extent, be accentuating a normal process. Clinical support for such a method rests upon an impression that persons with adhesive pericarditis and coronary disease do not exhibit evidence of myocardial ischemia to the same degree that other persons do. Adequate statistical evidence is not available to make this more than an assumption, but case reports to this effect have appeared in the literature from time to time (Thorel, 1903, and Anrep, 1936). Opposed to the idea is the knowledge that pericarditis, if constrictive, can impair cardiac function and the assertion of Beck and Tichy (1935) that the visceral pericardium acts as an effective barrier to the transference of new blood into the myocardium from without.

Study of the available clinical and pathologic evidence concerning the effect of pericardial and of pleuropericardial adhesions on heart function indicates that ordinary obliterative pericarditis as is seen frequently in rheumatic heart disease does not interfere with heart function. It is only when the pericardial sac becomes markedly thickened, sometimes calcified, by progressive disease that interference with the venous return to the heart occurs. Pleuropericardial adhesions, likewise, have little effect unless they become thick and firm, when they may, in the presence of an adherent pericardium, cause the heart to expend energy in pulling in all directions upon relatively unyielding structures. Such adhesions are more significant laterally than anteriorly because, under normal circumstances, the anterior chest wall is unyielding and becomes more so with advancing age and, thus, in the age periods with which we are concerned in this problem.

Previous surgical efforts to revascularize the myocardium have been chiefly of three types. Beck (1935) advocated the use of a graft from the pectoral muscles. This was sutured to the myocardium after the removal of a portion of the parietal pericardium and a roughening of the visceral pericardium. O'Shaugnessy (1936) used a pedicled omental graft brought up into the chest through the diaphragm, using the thoracic approach to secure the omentum. Lezius (1937) grafted the

surface of the lung to the myocardium in dogs by suture, and in addition, he used a 30 per cent solution of flavine to stimulate the formation of adhesions. All of these methods in animals have resulted in the formation of adhesions between the graft and the myocardium which contained blood vessels sufficient in size and number to serve effectively as a source of collateral circulation to the heart. In human beings the operations of Beck (1937) and of O'Shaugnessy (1937) have yielded encouraging clinical results, but the amount of autopsy material available to give definite evidence as to the state of the graft and the amount of effective collateral circulation is still meager. Experience has shown that it is unsafe in the human being to suture the graft to the myocardium because of the danger of thereby producing ventricular fibrillation. As a consequence, the degree of union between the graft and the myocardium is uncertain. Because of this, it was decided that it would not be without merit to devise an operation which would not require the application of sutures to the myocardium and which would still with certainty produce union between the source of the collateral circulation and the myocardium. The procedure developed consists in the production of a sterile, adhesive, but nonconstrictive, type of pericarditis and the suturing of the pericardium to the retrosternal tissues in which course the intercostal and the internal mammary arteries.

EXPERIMENTAL WORK

Dogs were used as experimental animals. Under nembutal anesthesia, the pericardium was approached through a right- or left-sided thoracotomy in the fifth interspace. Respiration was maintained by positive pressure ventilation through an intratracheal catheter. The pericardium was opened anteriorly for a distance of 2 cm., and 3 c.c. of 2 per cent procaine was injected into the sac. After five minutes this was sucked out, and 2 c.c. of sodium morrhuate (½ of 1 per cent to 5 per cent) was injected. To this was added 0.4 Gm. powdered aleuronat or 0.7 Gm. of lionite No. 60 (carborundum sand). The pericardium was closed with interrupted silk sutures. The parietal pericardium was then sewn to the retrosternal tissues over an area 3 cm. square by means of interrupted silk sutures. The surfaces so approximated were first moistened with 5 per cent sodium morrhuate. The chest was closed without drainage.

Sixty dogs were operated upon in this manner without any appreciable disturbance in heart function at operation (Fig. 1). The only effect noted on application of the sodium morrhuate to the heart surfaces was a temporary tachycardia. The postoperative course of the animals was usually uneventful. Four dogs were lost from distemper, and one from interference with the venous return from the abdomen. This was probably effected by a kinking of the inferior vena cava. No animals developed pericardial effusion to a degree sufficient to interfere with their cardiac function. Dogs so operated upon have been maintained in perfect health up to six months, with an apparently normal cardiac reserve. Animals were sacrificed at intervals of from three weeks to six months after the operation to determine the degree of collateral circulation.

At autopsy highly vascularized fibrous adhesions were found between the retrosternal tissues and the pericardium (Fig. 2). These varied in length from 0.5 to

3 cm. It is important to note that the adhesions became of sufficient length to allow considerable motion of the heart. The operative procedure thus did not result in as much fixation of the heart to the retrosternal tissues as was anticipated. In all instances, an adhesive pericarditis was present. This was somewhat patchy in its distribution, and in no instance was it of sufficient degree to be constrictive. The adhesions between the pericardial surfaces were finely fibrinous in the dogs sacrificed early and fibrous in cases of longer duration. The pericardium could be separated from the myocardium without great difficulty. The results warrant the belief that the site of pericardial adhesions can be localized fairly well by the use of the aleuronat and the lionite which tend to adhere where placed and, when applied in a streaky manner, leave the intervening pericardium thin and relatively free of adhesions.

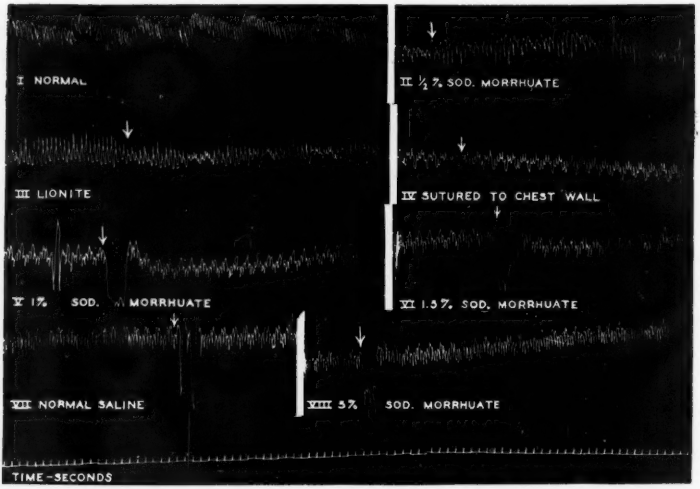

Fig. 1.—Blood pressure tracings made with a mercury manometer to show the effect upon blood pressure and heart action of the various operative procedures referred to in the text. The blood pressure dropped from 130 mm. of mercury, record I, to 103 mm., record II, after opening the pericardium, and remained at about that level throughout the experiment. The heart action is not disturbed appreciably by the various concentrations of sodium morrhuate used. The large deflections in the tracings are the result of the mechanical effect of putting the solutions into the pericardial sac and, therefore, are present even when the injection fluid is normal saline, record VII.

The degree of effective anastamoses was demonstrated by the injection method, using a fluid consisting of 120 c.c. of Higgin's eternal ink No. 812 in 1,000 c.c. of water, to which was added 5 per cent commercial gelatin and 5 per cent potassium iodide. The aorta was clamped just above its origin. The superior vena cava, the azygos vein, and the inferior vena cava were clamped so that no fluid was able to enter the heart chambers. A small puncture wound was made into the left ventricle to permit the escape of the injection fluid. This was found necessary because the extensiveness of the anastomotic channels sometimes resulted in a filling of this heart chamber. Perfusion of the heart was carried out through a cannula inserted into the right carotid artery at 120 mm. mercury pressure for thirty minutes, using approximately 1 liter of injection fluid after first washing out the vascular bed for thirty minutes with warm normal saline solution. After completion of the injection, the heart was opened to make certain that no normal channels entering directly into the heart chambers had escaped clamping.

Grossly, the injected heart showed a rich vascularization of the adhesions and of the pericardium. The main branches of the coronary arteries were seen to contain injected fluid. After the injection, the hearts were fixed in 10 per cent formalin, and portions freshly sectioned by the freezing method or dehydrated, embedded in paraffin, sectioned, and counterstained with eosin. By these methods the presence of an abundant supply of carbon in the larger and smaller vessels of the entire myocardium was demonstrated in all cases (Fig. 3). Control hearts injected in a similar manner failed to reveal dye in the vessels of the myocardium.

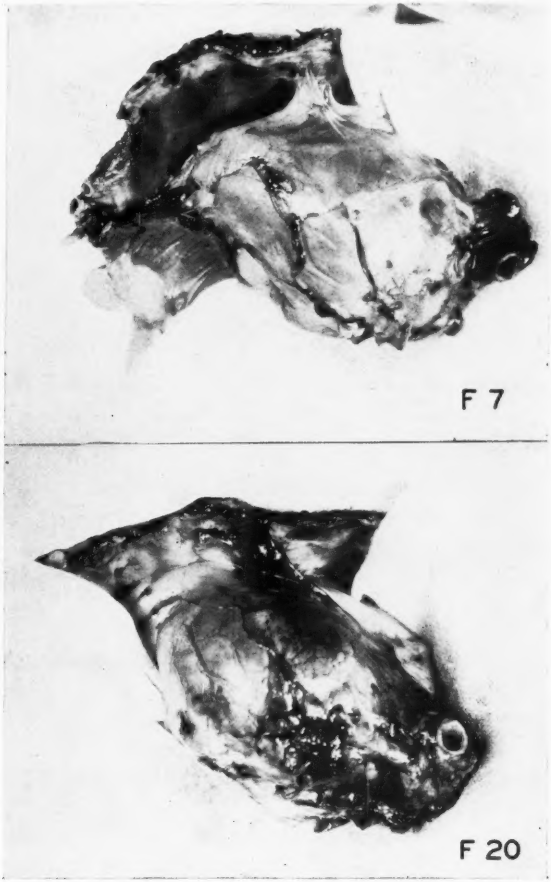

Fig. 2.—Photographs of hearts of Dogs F7 and F20, five months and four months, respectively, after operation in which an adhesive pericarditis was produced by 0.5 per cent sodium morrhuate plus aleuronat and in which the pericardium was sutured to the retrosternal tissues after perfusion with ink solution. Note the many adhesions between the heart and retrosternal tissues, and also note that their length is adequate to permit considerable motion of the heart. Vessels filled with carbon particles are in evidence on the heart surfaces.

The functional capacity of the hearts of animals subjected to the operation has been tested in a number of ways and found to be quite satisfactory. The dogs have been observed to play, run, and fight in the animal quarters in a manner

Fig. 3.—Photomicrograph of cross section of the left ventricle of Dog F4 operated upon two months previously and after perfusion with ink. Note the blood vessels filled with carbon, indicating the presence of a functioning collateral circulation. (×300)

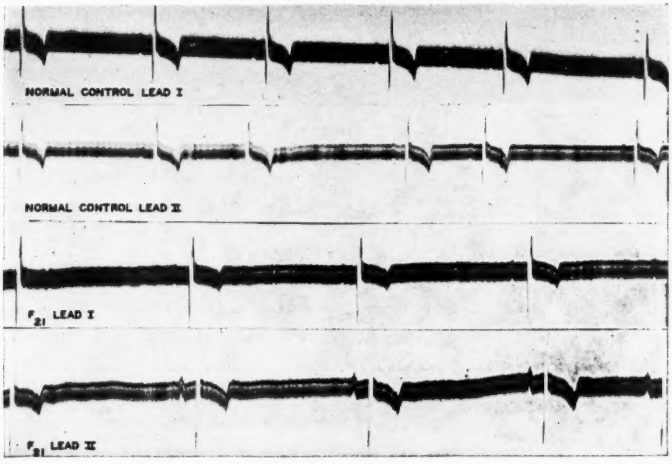

Fig. 4.—Electrocardiograms (two leads) of a normal dog and one, F21, with an adhesive pericarditis plus pericardioretrosternal adhesions. Note that the potentials of the control and the operated animal are of equal amplitude and of normal character. There is some sinus arrhythmia in both, but no more than is found normally in dogs.

indistinguishable from the normal. Their electrocardiograms (Fig. 4) show a normal potential amplitude and a normal heart mechanism. Roentgenokymograms of the heart (Fig. 5) show a normal degree of expansion and contraction. This

Fig. 5.—Roentgenokymograms of the hearts of (1) a normal dog, (2) Dog F21 five months after operation in which 0.5 per cent sodium morrhuate, plus aleuronat, was used to produce an adhesive pericarditis and retrosternal adhesions, and (3) Dog F13 two months after 5 per cent sodium morrhuate, plus aleuronat, was used to produce an adhesive pericarditis and retrosternal adhesions. Note that the heart expansion and contraction in both operated dogs are as great as in the normal animal. Autopsies demonstrated that the normal dog did not have an adhesive pericarditis and that both the other dogs had well-developed adhesive pericarditis, with an effective collateral circulation demonstrated by ink injection through pericardioretrosternal adhesions.

is considered adequate evidence that the type of pericarditis produced is not constrictive.

After showing that by the method described it is possible with safety to develop a vascular bed which should serve to supply a rich collateral circulation to the myocardium of the experimental animal, it seems warranted to advocate its application to human cases of myocardial ischemia. The question as to the type of patients suitable for the operation described naturally arises. The ideal case would be one in which the coronary occlusion is limited to the opening of the vessels, as seen in cases of aortic disease. The coronary vascular bed, especially in younger persons, would then be normal and best suited for the establishment of collateral connections. It is not believed to be necessary to limit the choice to such cases. All cases of myocardial ischemia due to occlusive disease of the coronary arteries should be benefited. The earlier in the disease that collateral circulation is established, the better should be the result.

SUMMARY

An operation is described which, in the dog, results in the development of a vascular bed which might possibly serve as a pathway for an effective collateral circulation to the myocardium.

It consists essentially in the production of a sterile adhesive pericarditis and the suture of the anterior parietal pericardium to the retrosternal tissues.

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DISCUSSION

DR. DUANE CARR, MEMPHIS, TENN.—This is certainly an outstanding and beautiful piece of experimental work. There is one point which escaped me during the presentation. I would like to ask whether or not it has been attempted, after the establishment of collateral circulation, to tie off the coronaries and see if the established circulation is sufficient to carry on the life of the dog?

DR. PETER HEINBECKER.—We have not yet tied off any of the coronary arteries of these animals, but we have some thirty animals ready for the procedure which will be attempted this fall.

ACUTE PUTRID ABSCESS OF THE LUNG

IV. Surgical Treatment and Results in Eighty-Six Consecutive Cases

Harold Neuhof, M.D., and Arthur S. W. Touroff, M.D.
New York, N. Y.

IN 1938[2] we presented an analysis of forty-five consecutive operative cases of acute putrid abscess of the lung (of less than six weeks' duration) and the conclusions derived from a study of these cases. The present report is based upon eighty-six consecutive operative cases of acute abscess, forty-one having been added since the former communication. Certain points which were previously made are germane to the present paper. Evidence was presented to place acute abscess of the lung in the category of surgical diseases; to prove that the acute lesion, because of its pathologic features, is usually readily amenable to surgical treatment; to indicate that the operative mortality is low; and to demonstrate that the immediate and end results of operation are good. This communication will be concerned with features which are essentially of surgical interest. It is hoped that a number of aspects of the subject, regarded as debatable at the present time, will be clarified by an analysis of the eighty-six cases.*

In sixty-five of the eighty-six cases, the abscess was situated entirely within the lung; in twenty-one, the abscess had perforated into the pleura before operation. An insignificant pulmonary abscess may be, and often is, the source of a putrid pleural infection. The perforated abscesses of this series, however, were all substantial lesions in which operative treatment was carried out upon the pulmonary lesion as well as upon the pleural infection.

Some aspects of the question of etiology remain controversial and, having no apparent surgical bearing, will not be discussed in this paper. Table I indicates the etiology in the cases in our series.

The lung was not the site of a pre-existing lesion in the great majority of the cases in this series. The term "primary abscess of the lung" may be employed, therefore, to designate these cases. There were, on the other hand, a number of cases in which an acute abscess was derived, apparently by the mechanism of "spillover," from a pre-existing chronic pulmonary abscess. There were also a few cases of

Read before the Twenty-Second Annual Meeting of The American Association for Thoracic Surgery at Los Angeles, Calif., July 5, 6, and 7, 1939.

From the Mount Sinai Hospital, New York.

*Brief reference should be made to the use of sulfapyridine which has revolutionized the treatment of a variety of acute pulmonary infections. Sulfapyridine was administered in three of our recent cases, without evidence of a beneficial effect on the course of the disease. All three came to operation as severe or fulminating cases.

acute pulmonary abscess which were due to direct extension from the mediastinum (Table II).

TABLE I

ETIOLOGY IN EIGHTY-SIX CASES

Aspiration (tonsillectomy, tooth extraction, spillover, etc.)		24 cases
Aspiration assumed		45
A. General anesthesia, acute tonsillitis, epilepsy	7	
B. Gross gingivodental infection	38	
Extension from mediastinum		3
Direct thoracic trauma		1
Sepsis (embolic abscess)		1
Undetermined		12

TABLE II

PRE-EXISTING INTRATHORACIC INFECTION IN EIGHTY-SIX CASES

None	77 cases
Subacute or chronic pulmonary abscess	6
Mediastinal abscess	3

TABLE III

CLINICAL COURSE AND OPERATIVE INDICATION IN EIGHTY-SIX CASES

Course severe, rapidly progressive, or fulminating; imperative indication	28 cases
Perforation of abscess into pleura; imperative indication	20
Fluctuating, remitting, or essentially stationary; elective indication	38

Our indications for operative treatment of acute putrid abscess are based upon the course of the disease. Our estimate of the course of a case includes a consideration of the following features of lung abscess: hemoptysis, foul sputum, febrile curve, toxemia, and the roentgenologic appearance of the lesion. In our opinion, an evaluation of all these features is essential. Cases in which the course was satisfactory and in which operation therefore was not indicated are not listed in Table III. Early in our experience, operation was performed only in those cases in which the course was clearly in the direction of a fatality. In such cases, the indication was regarded as imperative. With increasing experience in precise localization of lesions, and with the development of a surgical technique which yielded satisfactory results, the indications have been broadened. Operative indications can be regarded as imperative only when the course is obviously severe, fulminating, or rapidly progressive, or when spontaneous perforation into the pleura has occurred. In all other cases the indication must be regarded as elective because spontaneous recovery conceivably may occur. The proportion of imperative to elective indications is shown in Table III.

A thorough consideration of the roentgenologic features of acute pulmonary abscess is so vital in surgical treatment that all available information should be obtained regardless of the apparent simplicity of a case. The subject of the roentgenologic features of acute pulmonary abscess has been dealt with fully elsewhere.[3] It is referred

to at this juncture in order to point out that the surgical indications in any given case are not modified by the absence of a "typical" film. Thus, an operative indication may exist in the presence of a cavity containing a fluid level, or in the presence of a circumscribed area of density. Table IV demonstrates that the roentgenogram was not typical in the majority of cases of acute pulmonary abscess which came to operation.

TABLE IV

ROENTGENOLOGIC FEATURES IN EIGHTY-SIX CASES

"Typical"	17 cases
Pneumonic infiltration only	11
Pneumonic infiltration with areas of rarefaction	29
Pneumonic infiltration with cavity	9
Perforation into pleura; pleural fluid level	20

Bronchoscopy is imperative before proceeding with operation for acute abscess of the lung whenever aspiration of a foreign body is suspected. It is also indicated for purposes of precise localization of the bronchopulmonary segment in which an abscess exists, when such localization by roentgenograms remains in doubt. However, lesions can be localized accurately in the vast majority of cases by careful study of roentgenograms made in appropriate positions. Thus, in our opinion, bronchoscopy is necessary only when the clinical course or roentgenologic film suggests the existence of a lesion other than acute abscess of the lung (Table V).

On the basis of roentgenograms alone or in conjunction with bronchoscopy, the lesion was encountered at operation at the predetermined site in the great majority of instances. Errors in localization are referable to our incorrect roentgenologic interpretation of the site of contact between the abscess and the thoracic cage or to faulty counting of ribs at the time of operation (Table VI).

TABLE V

DIAGNOSTIC BRONCHOSCOPY

In the first 45 cases	20 times
In the second 41 cases	12 times

TABLE VI

OPERATIVE EXPOSURE OF UNPERFORATED ABSCESS AND OVERLYING ADHESIONS

Accurate exposure of visceroparietal adhesions	55 operations
Accurate exposure, interlobar or other nonparietal adhesions	6
Exposure immediately adjacent to adhesions (slight error)	10
Exposure distant to adhesions (gross error)	1
	72 operations

TABLE VII

DURATION OF DISEASE BEFORE OPERATION IN EIGHTY-SIX CASES

Up to two weeks	13 cases
Up to four weeks	40
Up to six weeks	33

The time at which operation was performed is divided empirically in Table VII into three periods of two weeks each. Of surgical importance is the fact that a lung abscess existed as such in all of the cases which were operated upon within the first two weeks of the onset of pulmonary symptoms. The pathology of acute abscess at operation is outlined in subsequent paragraphs. The point to be emphasized here is that the characteristic gross pathologic features of acute putrid pulmonary abscess were well developed within the first two weeks. There is, therefore, no support for the view that early operation is contraindicated on the assumption that the early lesion consists of an ill-defined area of gangrenous pneumonia.

An argument advanced in favor of a conservative attitude toward surgical intervention for acute abscess is based upon a widely held belief that death is excessively rare during the acute period of the disease. It is also generally assumed that the condition of the lesion during this period remains more or less stationary. Neither assumption is justified by our experience. We wish to make three points: First, there were a number of deaths during the years in which acute abscess was not operated upon at Mount Sinai Hospital. Second, there were a large number of cases (Table III) in which operation was undertaken because of an imperative indication. In not a few of these, death would have occurred if operation had not been performed. Third, the patient's status potentially is ominous in any instance in which spread of infection occurs. Table VIII contains significant information concerning the proportion of cases in which spread occurred during observation in the hospital. Instances of spread to or through the pleura are of special interest. The most serious extensions, however, are to other pulmonary areas in the same or in the opposite lung via the bronchial tree (spillover). This complication, occurring before the pulmonary abscess was opened, was the cause of one, and the probable cause of another, death in our series. In view of the fact that there were only three deaths among the eighty-six operative cases, the seriousness of spillover is evident (Table VIII).

TABLE VIII

SPREAD OF LESION DURING PREOPERATIVE OBSERVATION IN EIGHTY-SIX CASES

Increase in size	29 cases
Perforation into pleura	5
Spillover	7
No spread	14
No preoperative observation (chiefly because of urgency)	31

TABLE IX

PATHOLOGY AT OPERATION FOR UNPERFORATED ABSCESS

A. Contents	
Foul pus; free or attached gangrenous sloughs	66 cases
Little or no foul pus; adherent gangrenous sloughs	7
Bronchial fistula or fistulas at operation	63

The foregoing considerations and tabulations are concerned with preoperative aspects of acute putrid pulmonary abscess. The remainder of this paper deals with the pathology as encountered at operation, some aspects of technique of operation, and the results of surgical treatment. For reasons which will be indicated, more than one operation was performed in some cases. Tables dealing with operative findings will, therefore, have greater totals than the total number of patients.

The description of the pathology of acute abscess as encountered at operation has been set forth fully elsewhere.[1, 2] Only those features which are of surgical significance are tabulated in this paper. Acute abscesses containing adherent gangrenous sloughs and little or no pus are unusual and were encountered chiefly in the very early stage of the disease (Table IX). Presumably, they would have progressed to pus-containing lesions with or without adherent pulmonary sloughs had the operations not been performed. Essentially the same type of operative procedure was carried out under both circumstances, and there appears to be no good reason for any difference in technique. Bronchial fistula is referred to in Table IX because the demonstration of one or more bronchial fistulas at operation is evidence that the abscess has been entered. As stated elsewhere,[1, 2] the presence of one or more bronchial orifices in the wall of the cavity constitutes an essential feature of the pathology of putrid abscess of the lung. There are occasional instances in which such orifices are blocked by pus or blood clot or detritus. Therefore, it should be stated that bronchial fistulas were observed postoperatively in *all* cases whether or not they were seen at operation (Table IX).

The purpose of calling attention to the substantial proportions of pulmonary abscesses is to emphasize the necessity of disclosing fully the lesion at the time of operation. The assumption that an abscess has been adequately entered and cared for when a small collection of foul pus has been encountered and a small cavity disclosed is likely to be incorrect. In our experience, an inadequate operation is often followed by the continuation of symptoms of putrid abscess, extension of the lesion, and spillover. In general, it may be stated that the size and shape of the abscess disclosed at operation should approximate the size and shape of the lesion in the preoperative film (Table X).

TABLE X

PATHOLOGY AT OPERATION FOR UNPERFORATED ABSCESS

B. Size of Lesion	
1-2 inches in diameter	33 cases
2-3 inches in diameter	21
3-4 inches in diameter	16
4-5 inches in diameter	3

Although at various times we have advanced evidence to demonstrate that all acute abscesses are situated superficially within pulmonary lobes, our viewpoint apparently has not been generally ac-

cepted. Thus, "central abscess of the lung" is a term that is employed frequently at the present time. We now offer further evidence in support of our contention, based upon a larger series of operative cases. In every one of the eighty-six cases (ninety-four operations for acute abscess), only a thin shell of lung separated the abscess from the visceral pleura. When a thicker shell of lung was traversed, the site of approach was found to be incorrect. Abscesses facing fissures, the mediastinum, or the diaphragm comprise the lesions in which the diagnosis of central abscess usually is made. These abscesses, which are not common, are deeply situated in relationship to the *costal* surfaces of pulmonary lobes. They are, however, as superficial in relationship to other surfaces of the lobes as abscesses facing the thoracic parietes. For example, an abscess facing an interlobar fissure may be situated an inch or two from the costal surface of the lobe. A considerable thickness of lung would have to be traversed in order to enter such an abscess from the costal surface. However, on separating the adhesions between the two lobes and approaching the lesion through the fissure (the correct surgical approach in such a case), the abscess is found to be situated superficially in the lobe and to bulge into the fissure. Too much emphasis cannot be placed upon the superficial situation of acute putrid pulmonary abscess because this feature offers the key to ready operability in this disease (Table XI).

TABLE XI

PATHOLOGY AT OPERATION FOR UNPERFORATED ABSCESS

C. Situation of Abscess Within Lobe	
Superficial, facing thoracic cage	67 cases
Superficial, facing fissures (interlobar)	3
Superficial, facing diaphragm	2
Superficial, facing mediastinum	1
Deep	0

If pulmonary abscesses are situated superficially, overlying pleural adhesions must, of necessity, be the rule, for one is a corollary of the other. The fact is that adhesions were encountered over the abscess in every case in our experience (Table XII).* Furthermore, the adhesions were both extensive and dense in the great majority of instances. Therefore, a one-stage operation conducted entirely through the zone of limiting adhesions could be carried out in most cases. *Parietal* adhesions in the region of an interlobar or mesial abscess may be scanty or absent, but under such circumstances, the adhesions related to the abscess lie within the fissure or over the mediastinum, respectively. Similarly, parietal adhesions over a paravertebral abscess may be scanty, but denser adhesions exist at the mediastinal parietal pleura toward

*Exceptions may be met with in the future, but at the present time we believe we are justified in asserting that acute putrid pulmonary abscess without overlying adhesions does not occur.

which paravertebral abscesses often point. In other words, the operative exposure of scanty and limited (or absent) adhesions (with the exceptions that have been made), indicates that the abscess is not "pointing" in the operative field.

TABLE XII

PATHOLOGY AT OPERATION FOR UNPERFORATED ABSCESS

D. Pleural Adhesions over the Abscess	
Facing thoracic cage (visceroparietal)	67 cases
Interlobar (viscerovisceral)	3
Diaphragmatic (viscerodiaphragmatic)	2
Mesial (visceromediastinal)	1
Adhesions absent	0

TABLE XIII

OPERATIVE PROCEDURE

Partial excision of one rib	66 times
Partial excision of two ribs	26
Partial excision of three ribs	2
Local anesthesia	52
General anesthesia	42
Unroofing of abscess	89
Partial unroofing of abscess	5
Gauze pack of abscess cavity	93
Tube drainage of abscess cavity	1

Since our operative technique has been described elsewhere,[1] reference will be made at this time only to some of the essential details (Table XIII). The use of local anesthesia in the majority of cases is to be noted. General anesthesia is employed only rarely at the present time. The removal of a portion of only one rib sufficed in the majority of instances for a satisfactory operation upon the pulmonary abscess, and this indicates clearly that the removal of large portions of several ribs for wide exposure of the lesion is unnecessary. The point to be emphasized is that local and limited removal suffices for an adequate operation, provided the lesion is localized precisely. Indeed, the excision of too liberal a portion (more than four inches) of a single rib may expose the uninvolved pleura and thereby invite accidental entry, even when the exposure is placed accurately over the abscess. The other aspects of operative technique to which we shall refer are concerned with methods of entry of the abscess, unroofing, and drainage. We advocate clean-cut entry of the abscess after its presence has been revealed by aspiration. This point has already been made, but our additional experience has served to emphasize its importance, since the remainder of the operation is greatly simplified by this essential first step. The cutting grooved director and double-edged scissors which we employ are most useful for this purpose. The use of the cautery or of other blunt methods of opening the abscess or enlarging the opening is unnecessary. The opening, once made, is enlarged freely by removing with a scalpel the thin shell of lung overlying the abscess.

The technique of "unroofing," which is an essential step of the operation, has been detailed elsewhere.[1] Packing of the abscess cavity with gauze and not tube drainage follows naturally an unroofing operation. The great rarity of tube drainage, as noted in Table XIII, reflects our opinion on this aspect of the operation.

A one-stage operation is always performed when adhesions agglutinating the pleurae occupy the operative field. Early in our experience, two-stage operations were performed when the pleura was opened accidentally or intentionally. The death which followed one such operation was due, at least in part, to pleural infection which occurred between the two stages. Since that time we have performed two-stage operations only rarely, regardless of whether or not the free pleural space was opened. Table XIV indicates the infrequency of two-stage operations. The precautions taken to avoid the occurrence of postoperative empyema have been described elsewhere.[1] That they were successful is proved by the fact that empyema following a one-stage operation in which the free pleura was opened occurred in only a single instance. The two other cases of empyema listed in Table XV followed two-stage operations.

TABLE XIV

ONE- AND TWO-STAGE OPERATIONS IN UNPERFORATED ABSCESS OF THE LUNG

One-stage operation	
Through adhesions; free pleura not opened	55 cases
Through adhesions; free pleura opened	13
Two-stage operation	5

The influence of operation upon the general and special symptoms of acute pulmonary abscess was usually dramatic. The effect of operation also was lasting. Recovery cannot be anticipated in every case, despite an adequate operation. Thus, it is of interest to note that, in one of our fatal cases (Table XVII), expectoration of foul pus ceased promptly, but chills and fever (unique in our experience), which had dominated the preoperative picture, continued unabated. By way of contrast, there were several nonfatal cases in which the symptoms of pulmonary abscess continued after operation (Table XV). They will be discussed below as instances in which additional operations were necessary because of primary incomplete or inadequate procedures.

TABLE XV

POSTOPERATIVE COMPLICATIONS REQUIRING ADDITIONAL OPERATION

Empyema	3 cases
Secondary abscess of the lung	
A. Due to incorrect primary surgical approach	1
B. Due to inadequate primary operation	4
C. Due to spillover	3

The postoperative course was usually uneventful. Complications were few in number and, for the most part, not serious (Table XV).

The absence (with a single exception) of empyema after one-stage operations in the presence of an opened free pleura is worthy of special note. There was no instance of serious postoperative hemorrhage. Another feature was the rarity of cerebral embolization. The formation of a pulmonary abscess adjacent to the one operated upon, or an extension from an inadequately unroofed loculation, was due to incorrect surgical approach, inadequate operation, or spillover. Thus, a number of additional operations for pulmonary abscess were necessary (Table XV). Such operations were performed through existing wounds or through new incisions usually adjacent to the original wound. The procedure carried out upon the second abscess was not different from that upon the original lesion.

TABLE XVI

SUBSEQUENT OPERATIONS RELATED TO THE ACUTE ABSCESS

Revision because of premature closure of wound	2 cases
Transplantation of fat for open bronchopulmonary defect	3

For purposes of completeness, reference will be made to *late* thoracic operations related to the acute abscess. They were few in number because wounds usually healed with obliteration of the pulmonary cavity and remained healed. In two cases (Table XVI), however, there was recurrence of symptoms due apparently to premature closure of the wound. Both patients progressed satisfactorily after the wounds were reopened, and drainage of the original pulmonary cavities was re-established. As we have pointed out elsewhere, the most important aspect of postoperative treatment is concerned with the maintenance of an adequate bronchial fistula until all pulmonary infiltration has subsided (proved by x-ray film) and the clinical evidence of anaerobic infection has disappeared. In most cases, the problem has been to maintain, rather than to close, the fistula. There were two cases, however, of long-lasting open bronchopulmonary fistulas, and a third case in which

TABLE XVII

RESULTS OF OPERATION

Operative deaths			3 patients
From empyema and cerebral embolism		1	
From continuation of sepsis		1	
From spillover during preoperative observation		1	
Operative recoveries			83 patients
Number of operations for acute putrid abscess			94 operations
Follow-up (up to 14 years)			83 patients
Cured*		73	
Improved (short follow-up)		10	
A. Recent operations	3		
B. Lost from follow-up	3		
C. Death from unrelated causes (see text)	4		
Unimproved		0	

*Two late unrelated deaths from carcinoma of the stomach and carcinoma of bladder.

the cavity was so large that a permanent fistula was anticipated. A plastic procedure for the closure of the bronchopulmonary cavity was employed, consisting essentially in the free transplantation of fat, a method previously described.[4] The cavities and fistulas were permanently closed thereby in these three cases.

The operative mortality is seen in Table XVII. The first death occurred early in the first series of cases and was due chiefly to an empyema and spillover infection which developed between the first and second stages of a two-stage operation. We believe that, with the present technique, the course would have been a different one. In the second case, death apparently was unavoidable, as already indicated. Death in the third case was anticipated before operation. The patient was suffering from a low-grade intraperitoneal infection after operation for a perforated duodenal ulcer and developed a right-sided postoperative pulmonary abscess. The latter, situated in the mesial lobe, was not associated with parietal adhesions. Because the abdominal symptoms dominated the clinical picture for a time, and the absence of parietal adhesions necessitated an extensive operative procedure, conservative (nonoperative) treatment was employed. When, however, evidence of spillover infection occurred, conservative treatment was abandoned. Because of the patient's desperate condition, a hasty one-stage drainage with incomplete unroofing was performed. Death occurred on the second postoperative day. Post-mortem examination revealed gangrenous bronchopneumonia (spillover), not only in the areas noted in the preoperative film, but also in the opposite lung. The pulmonary abscess was found to have been inadequately drained.

Ninety-four operations for acute putrid abscess were performed. The fact that there were eight more operations than patients is due to the development of additional abscesses as complications after the primary operation. These eight cases are listed in Table XV.

The results of operation can be stated briefly because they can be classified readily. There is a need for the term "improvement" following surgery in chronic pulmonary infection because of the nature of the disease and the problems that may be encountered, but there should be no place for the term as related to the surgery of acute abscess. In the follow-up after operations for acute abscess, we apply the term "improvement" only to a *temporary* state in which patients are doing well and are progressing definitely toward cure. We, therefore, apply it only to the first months after operation. Of the ten patients classed as improved, three are recent operative cases; three were lost from follow-up too soon after operation to be termed "cured"; four died from various causes (actinomycosis of the liver, suicide, the original chronic pulmonary abscess, strangulated hernia) unrelated to operation upon the acute pulmonary abscess, and also too soon to be termed "cured." There were two deaths from carcinoma (stomach,

bladder) at a time when the pulmonary abscess was cured. The latter was proved by clinical course and autopsy, and these two cases are included, therefore, among the "cured."

The term "cure," as employed by us, denotes complete freedom from symptoms, complete disappearance of roentgenographic evidence of pulmonary infiltration referable to pulmonary abscess, and negative bronchoscopy. According to these criteria, cure has been achieved in seventy-three patients, all of whom have had complete follow-up. These data warrant general acceptance of acute putrid abscess as a surgical disease, since operative treatment has yielded excellent results, with low mortality.

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DISCUSSION

DR. ETHAN FLAGG BUTLER, ITHACA, N. Y.—Dr. Neuhof and Dr. Touroff are successfully maintaining the Lilienthal tradition at Mount Sinai Hospital. Many of these cases have been presented before the New York Society for Thoracic Surgery. Their results have been convincing, and it would seem that early operation has earned a secure place. This is the more reasonable when one observes the rapidity with which putrid abscesses improve after free aeration of the abscess cavity.

THORACOPLASTY WITHOUT SECTION OF MUSCLES

RICARDO FINOCHIETTO, M.D.*
BUENOS AIRES, ARGENTINE

SINCE 1934 we have performed almost all thoracoplastic operations without cutting any muscles, sectioning them only when carrying out the typical procedures of Semb and Graf-Schmidt and in revision and extraperiosteal operations.

Roux, of Lausanne, in performing thoracoplasty used to conserve the fibers of the trapezius above the spine of the scapula. Picot, in performing paravertebral resection of the upper ribs, split the fibers of the trapezius and the rhomboideus. In 1928 and 1938 Head,[31, 32] of Chicago, proposed the removal of the ribs through posterior incisions with splitting of the muscular fibers. In the last few years some representatives of the French school[7] have also reduced the number of muscles to be sectioned. But before 1935, as far as we know, nobody published anything about extensive, superior, subperiosteal, subscapuloparavertebral thoracoplasty without sectioning or splitting any muscle. This subject we have developed ourselves[14, 17-20, 25] or caused to be developed[1-3, 8] in various publications. Since then, we have operated every year without section of muscles in the operative sessions of the postgraduate course of Professor Sayago and in the Buenos Aires Congress of Surgery.

We shall not be concerned here either with anterolateral and axillary thoracoplasty, which has been practiced for a long time without the sectioning of any muscles, or with lower thoracoplasty through the fibers of the latissimus dorsi proposed in 1928 by Head and practiced and published by ourselves in 1934-1935.[28] We shall consider only the upper or superior thoracoplasty of the upper four or six ribs. To carry out this operation we incise the skin and look for the surgical triangle (auscultatory triangle). We penetrate this and reach the costal wall from which we resect the ribs previously decided upon.

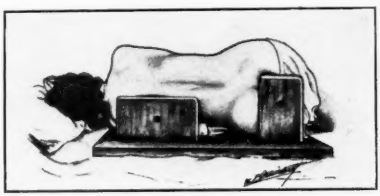

Fig. 1.

To perform the operation properly it is necessary to fulfill certain conditions. The patient must be well placed on the table and securely

*Surgeon, Hospital Rawson.

Received for publication, Dec. 27, 1938.

held by our chest support[11, 24] (Figs. 1 and 2) or by some other equally effective device. We use only local anesthesia by injection with the classical technique before making the skin incision and by a thorough injection of the periscapular and vertebral muscles and the intertransverse regions. The double facial arc of E. Finochietto[9] enables the first

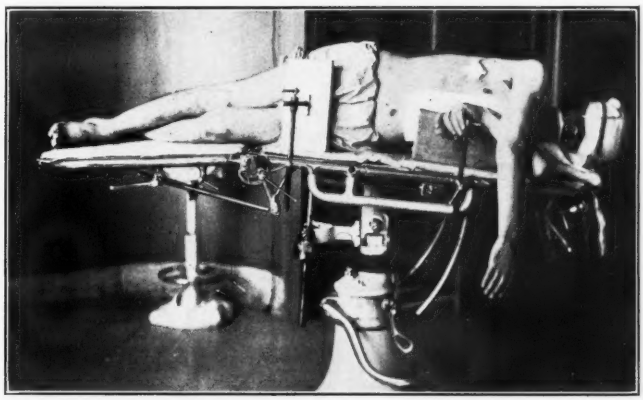

Fig. 2.

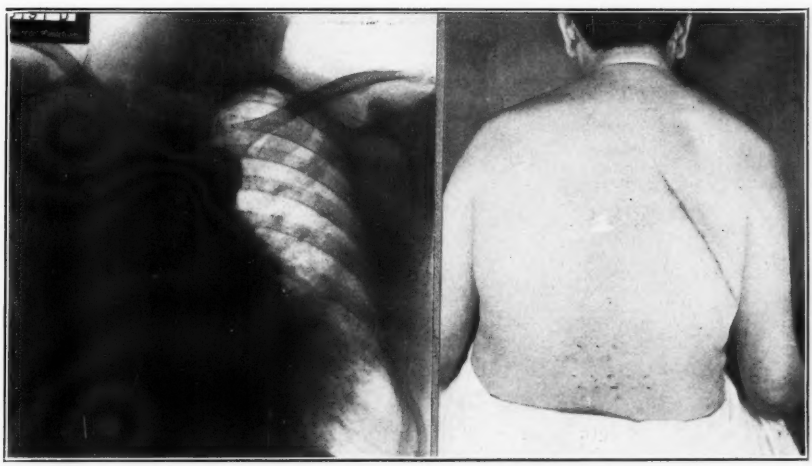

Fig. 3. Fig. 4.

assistant to stay at the head of the table and to move freely. It is absolutely indispensable to use long and solid instruments.[5, 12] Our periosteotome and raspatory are 35 cm. in length,[13, 15] and our scissors and bone rongeur, 30, 32, and 35 cm.[21, 23] Our Farabeuf retractor[30] is 8 cm., and the Vaccarezza valves[32] are 15 cm. in length.*

*All these instruments are manufactured by Lutz-Ferrando Co., in Buenos Aires, and by Collin, in Paris.

At first we used the Picot incision following the sixth or seventh intercostal space (Figs. 3 and 4), but since 1935 we have employed the paradoxical incision of E. Finochietto.[2, 3, 10, 18, 19] With this incision the operation is easier. After cutting the skin (Fig. 5) and the

Fig. 5.

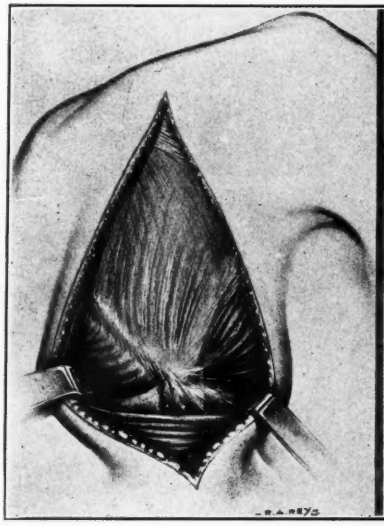

Fig. 6.

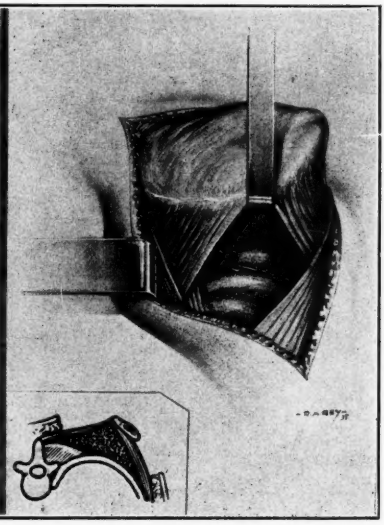

Fig. 7.

cellular tissue, it is very important to dissect the skin flaps for a distance of 5 cm. in order to diminish tension and to permit the

mobilization of the scapula. The superior border of the latissimus dorsi is dissected for a distance of from 6 to 8 cm. at either side of the incision, separating it well from the serratus magnus and from the thoracic wall (Fig. 6). We then look for the external border of the trapezius and separate it from the rhomboideus, taking care not to tear the veins which we encounter there between the two muscles. The cellular tissue which fills the surgical triangle is incised until a rib appears. Then the inferior angle of the scapula is forced upwards (Fig. 7), and with the finger, the lower slip of the serratus magnus is separated to the level of the eighth or ninth rib. Behind the posterior border of the serratus magnus there is a thick bundle of connective tissue[34] which is cut between two forceps. The lower border of the

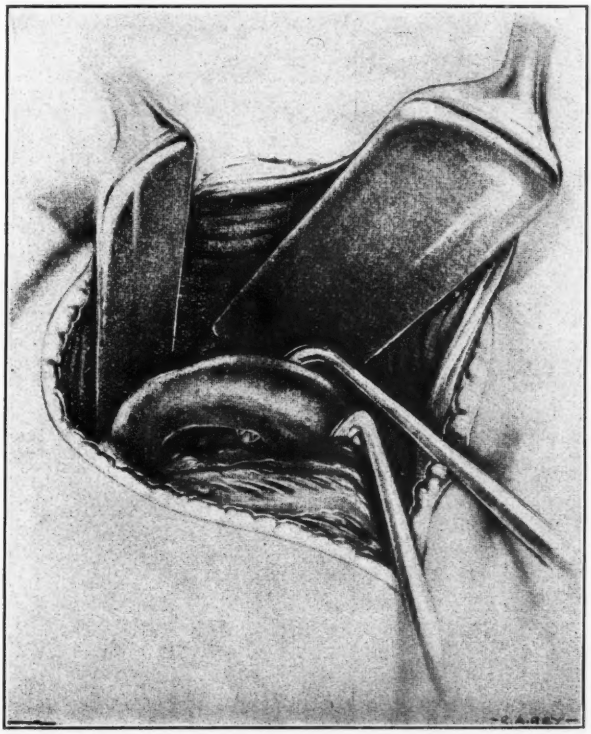

Fig. 8.

rhomboideus is then dissected with the scissors until the external aspect of the spinous processes is reached. The scapula is now elevated and forced out between the lips of the cutaneous incision, bringing with it the serratus magnus and rhomboideus (Fig. 7). With a tampon of gauze the thoracic surface is exposed, inward as far as the spinous processes, outward to the slip of the serratus magnus, and upward to the sec-

ond rib. The serratus posticus superior is excised.[14] Immediately and successively we detach the tendons of the vertebral muscles, push back the periosteum of the ribs, and cut off the desired length of them. Before resecting the second rib we push back the tendon of the strong slip of the serratus magnus. In order to resect the first rib it is necessary to have the retractor blades well placed and securely fixed (Fig. 8).

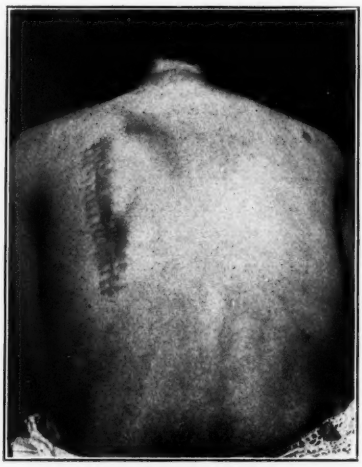

Fig. 9.

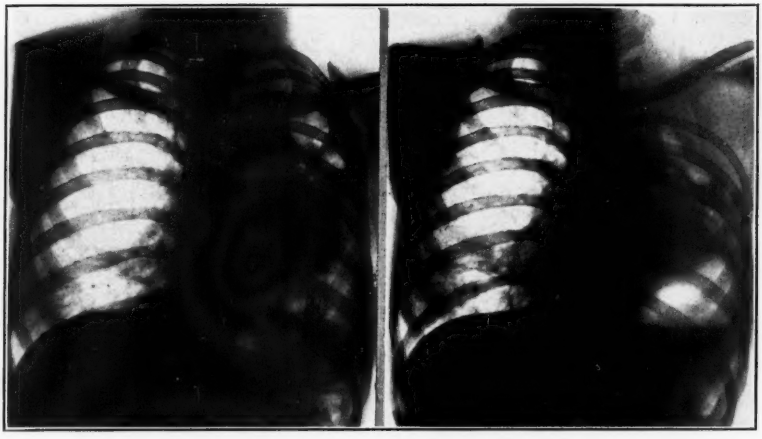

Fig. 10. Fig. 11.

Without difficulty, 5 cm. of the first rib can be resected; and with a little more effort and practice, removal to the scalenus anterior can be accomplished. After much training, the cartilage itself can be reached. Once having resected the first rib, the operation is finished because there is no need to suture any muscles. We close without drainage.

Our operation on the posterior wall of the thorax without sectioning the muscles has some restrictions. Without great difficulty we have operated upon patients weighing 80 kg. (176 pounds) and more (Figs. 4 and 14). Once we resected eight ribs, and often, when it was customary to remove many ribs at one time, we resected six or seven ribs in one stage. We have often approached the modern operation of the three upper ribs; but to accomplish this, it is necessary to resect a part of the fourth also.

Recently Dr. Villafañe Lastra,[35] of Cordoba, Argentine Republic, published reports of cases in which, using the paradoxical incision (Fig. 9) and without sectioning any muscles, he accomplished the paravertebral resection of the fourth rib; through this opening he performed an extensive subfascial extrapleural apicolysis. Immediately afterward he resected a large part of the third rib, almost all the second, and all the first (Figs. 9, 10, and 11). In a few weeks the large cavities (Fig. 10) disappeared (Fig. 11), and the sputum became negative.

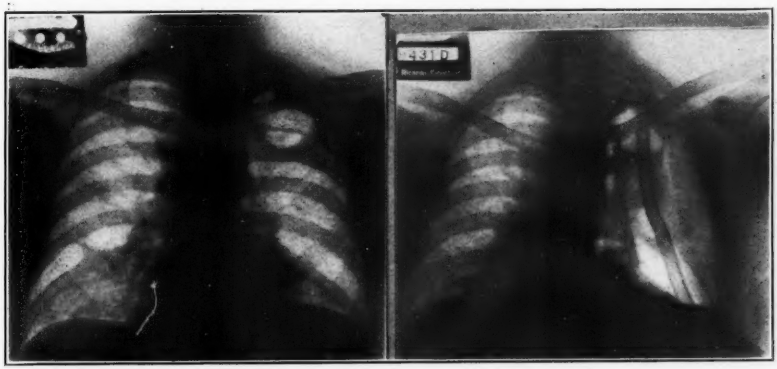

Fig. 12.

Fig. 13.

When we have considered it necessary, we have practiced the deferred resection of the first rib like Bernou and Fruchaud[6] or the deferred resection of the two upper ribs as we advised it[27] (Figs. 12, 13, 14, and 15). When we performed the Graf anterior-superior costal mobilization or the Schmidt modification we practiced the posterior stage of the operation by means of the paradoxical incision.[4] For the complete removal of the superior ribs we generally proceed in two stages: one retropectoral, and the other paradoxical, both without section of muscles. When we have needed to remove the transverse processes[26] we have had no difficulty (Figs. 16, 17). When a total thoracoplasty is begun from above, the middle and inferior stages can be accomplished by reopening the same paradoxical in-

cision (Fig. 16), or prolonging it in the same direction, or making an additional branching incision (Fig. 14) or another parallel incision (Figs. 18, 19), but always without sectioning any muscles. We have had many cases in which, combining the axillary and posterior approaches, we resected all the ribs of one hemithorax without sectioning any muscles.

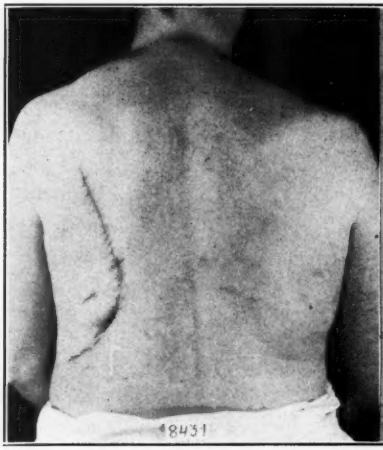

Fig. 14.

Fig. 15.

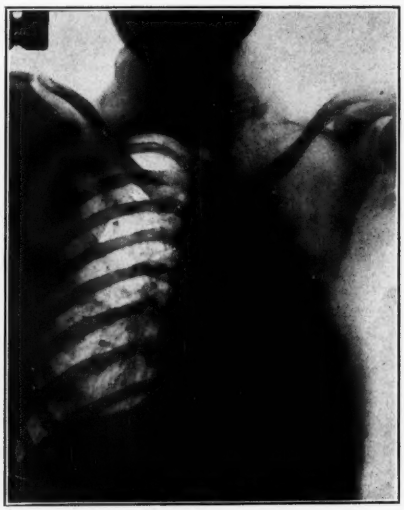

Fig. 16.

The paradoxical incision without muscular sectioning allows the removal of all the ribs with the following exceptions: when one wishes

Fig. 17.

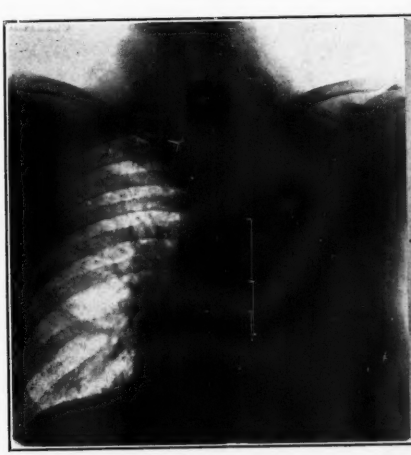

Fig. 18.

Fig. 19.

to resect only the two upper ribs; when it is necessary to perform a total resection of the three upper ribs by the posterior approach, without touching the fourth and without apicolysis; and finally, when extrafascial apicolysis or parosteal resection is necessary. In order to perform correctly paradoxical incision without muscle sectioning, it is necessary to be well acquainted with it and to have performed it on fresh cadavers, to have good instruments, good light, and the patient well and securely placed on the operating table.

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In Memoriam

NORMAN BETHUNE
1890-1939

Toward the end of November, 1939, in Wu Tai Shan, a Chinese town some two hundred miles southwest of Peiping, there died of blood poisoning Dr. Norman Bethune. His fatal illness followed a wound received while operating upon soldiers of the Chinese Army.

None of our members has had more stirring actions, and few, perhaps, more useful ones, crowded into the years of his life than had Norman Bethune, the stormy petrel, as Dr. Archibald aptly characterized him.

He was born in Gravehurst, Ont., in 1890, the son of a Presbyterian minister. His grandfather was a prominent Toronto surgeon. He studied medicine in the University of Toronto, went overseas before his course was completed, was wounded at Ypres in 1915, and returned

Norman Bethune giving a blood transfusion in a Madrid hospital.

to Toronto for graduation in 1916. He re-enlisted and served as surgeon-lieutenant in the British Navy on H.M.S. Pegasus until the Armistice. After studying abroad, he returned to Canada in 1924, working with Archibald at the Royal Victoria Hospital in Montreal and later heading a service of his own at the Sacre Coeur Hospital.

In the 20's and 30's he was in frequent attendance at our meetings and served as a councilor from 1933 to 1938. His "Compressionist's Creed"* is characteristic of his forceful, and occasionally fantastic, utterances. He invented many instruments; most useful are his excellent rib shears.

It was not, however, in a well-disciplined hospital that one saw the sinewy figure of Bethune at its best. His intense love of freedom, his intolerance of the reins of authority, and his human interests transcended his medical ones. He founded a Children's Art Center and a Group for the Security of the People's Health in Montreal. At the outbreak of the Franco revolt, he resigned his Canadian positions and went to Spain. In a short time he organized a blood bank and a Flying Transfusion Service in Madrid, which delivered stored blood to the various Republican fronts in central Spain. When this was running smoothly, he left, returned to the United States, and toured the country in behalf of the Spanish Republic. The war in China enlisting his sympathies, he set out with a medical unit after a short period of preparation. In central China he was reported lost and captured, but turned up safely, after losing contact with his army for a month and covering great distances on foot in order to rejoin it. A few of his adventures he described in newspaper and magazine articles; what his later ones were will probably remain unknown.

What better end could any man have than this fellow member of ours, who spent his life and met his death in the service of his ideals—Humanity and Freedom.

Leo Eloesser.

In a letter to Dr. Louis Davidson, New York, which was reprinted in the *Baltimore Evening Sun*, Jan. 13, 1940, Bethune, writing from China, said:

> "The work I am trying to do is to take peasants (boys) and young workers and make doctors out of them. They can read and write and most have a knowledge of arithmetic. None of my doctors has ever been to college or universities, and none has ever been in a modern hospital (most of them have never been in any hospital), much less a medical school. With this material, I must make doctors and nurses out of them—six months for nurses and one year for doctors. We have 2,300 wounded in hospitals all the time. These hospitals are merely the dirty one-story mud-and-stone houses of out-of-the-way villages set in deep valleys, overhung by mountains, some of which are 10,000 feet high."

Bethune described himself as having traveled during the last year 3,165 miles, performing 762 operations, and examining

*J. THORACIC SURG. 5: 330, 1936.

1,800 wounded. In addition, he reorganized the army's sanitary service, wrote three textbooks, and established a medical training school.

"It's a fast life," he wrote. "I miss tremendously a comrade to whom to talk. You know how fond I am of talking. I don't mind the conventional hardships—heat and bitter cold, dirt, lice, unvaried unfamiliar food, walking in the mountains, no stoves, beds, or baths. I find I can get along and operate as well in a dirty Buddhist temple with a twenty-foot high statue of the impassive-faced, gilded god staring over my shoulder, as in a modern operating room, with running water, nice green glazed walls, electric lamps, and a thousand other accessories. . . . They [the wounded] have no mattresses, no sheets. They lie in their old, stained uniforms with their knapsacks as pillows and one padded cotton blanket over them. They are grand. They certainly can take it."

Of his physical condition Bethune said: "My health is pretty fair—teeth need attention, one ear has been completely deaf for three months, glasses for eyes need correction, but apart from these minor things and being pretty thin, I'm O.K." He added, "I dream of coffee, of rare roast beef, of apple pie, and ice cream. Mirages of heavenly food! Books —are books still written? Is music still being played? Do you dance, drink beer, look at pictures? What do clean sheets in a soft bed feel like? Do women still love to be loved?"

Editor's Note.

The American Association for Thoracic Surgery

Officers

PRESIDENT, ADRIAN V. S. LAMBERT, New York, N. Y.
VICE-PRESIDENT, FRASER B. GURD, Montreal, Canada
SECRETARY, RICHARD H. MEADE, JR., Philadelphia, Pa.
TREASURER, I. A. BIGGER, Richmond, Va.
EDITOR, EVARTS A. GRAHAM, St. Louis, Mo.

Council

HAROLD BRUNN, San Francisco
FRANK B. BERRY, New York
FRANK S. DOLLEY, Los Angeles
ROBERT M. JANES, Toronto
DAN C. ELKIN, Atlanta

CONSTITUTION OF THE AMERICAN ASSOCIATION FOR THORACIC SURGERY

(AMENDED JULY 6, 1939)

Article I—Name

SECTION 1.—This Association shall be known as the American Association for Thoracic Surgery.

Article II—Object

SEC. 1.—The object of the Association shall be to encourage and stimulate investigation and study that will increase the knowledge of intrathoracic physiology, pathology and therapy, to correlate such knowledge and disseminate it.

SEC. 2.—To attain this object, the Association shall hold at least one scientific meeting every year in which free discussion shall be featured; shall conduct a Journal for the publication of the papers presented at this meeting, and other acceptable articles; shall sponsor and support a Registry for Chest Tumors; shall cooperate with other organizations working toward the same end; and shall undertake such other activities as the Council or the Association as a whole may decide.

Article IV—Membership

SEC. 1.—There shall be four classes of members: Active, Associate, Senior, and Honorary. Admission to membership in the Association shall be by election. Membership shall be limited, the limits on the respective classes to be determined by the By-Laws. The power to vote and the privilege of holding elective office are limited to active and senior membership.

SEC. 2.—Election to Active, Senior, and Honorary Membership shall be for life, subject to the provisions of Sec. 3, following. Election to Associate Membership shall be for a limited period of time, as determined by the By-Laws. During this limited period, an Associate member, if properly qualified, may be elected to Active membership. At the expiration of this limited period, an Associate member, if not yet qualified for Active membership, must either be re-elected to an additional period of Associate membership, or be dropped from the rolls of the Association.

SEC. 3.—Membership may be voluntarily terminated at any time by members in good standing. The Council, acting as a Board of Censors, may recommend the expulsion of a member on the grounds of moral or professional delinquency, and submit his name, together with the grounds of complaint, to the Association as a whole at any of the regularly convened meetings, after giving the member so accused ample opportunity to appear in his own behalf.

Article V—Officers and Government

SEC. 1.—The officers of the Association shall be a President, a Vice-President, a Secretary, a Treasurer, an Editor, and five Councilors. These ten officers and councilors shall be the governing body of the Association, and shall have full power to act in all matters, except as follows:

1. They may not alter the initiation fees or annual dues, nor levy any general assessments against the membership, except that they may, in individual cases, remit annual dues or assessments.
2. They may in no wise change the Constitution or By-Laws.
3. They may neither elect new members nor alter the status of existing members, other than to apply the provisions of Article IV, Sec. 2.
4. They may not deplete the principal of the Endowment Fund.

SEC. 2.—Officers and Councilors shall be elected at the annual meeting of the Association, *and shall take office upon conclusion of the meeting.** The President and the Vice-President shall be elected for a one-year term of office and neither may be re-elected to succeed himself in the same office. The Secretary, the Treasurer, and the Editor shall be elected for a one-year term of office, and any or all may be re-elected indefinitely. The outgoing President shall automatically become a Councilor for a one-year term of office. The other four Councilors shall be elected, one each year, for a four-year term of office, but no Councilor may be re-elected to succeed himself.

SEC. 3.—Vacancies occurring among the officers and councilors during the year shall be temporarily filled by action of the Council, subject to approval of the Association at the next regularly convened meeting.

Article VI—Committees

SEC. 1.—At the opening session of the annual meeting there shall be elected, after nomination from the floor of the Association, a Nominating Committee of three. This Committee shall prepare a slate of nominees for officers and councilors and shall present their report at the executive session of the Association.

SEC. 2.—The Council is empowered to appoint a Membership Committee, an Auditing Committee, a Program Committee, a Necrology Committee, and such other committees as may in its opinion be necessary. All such committees shall render their report at the executive session of the Association.

SEC. 3.—The Editor is empowered to appoint an Editorial Board, subject only to the approval of the Council.

SEC. 4.—The Association as a whole may authorize the Council to appoint Scientific or Research Committees for the purpose of investigating thoracic problems and may further authorize the Council to support financially such committees to a limited degree. In appointing such committees, the Council shall be governed by the provisions of the By-Laws.

Article VII—Finances

SEC. 1.—*The fiscal year of the Association shall run from the beginning of one annual meeting to the beginning of the next annual meeting.** The books of the Association shall be kept and audited on this basis.

*Amendment passed, first reading 1939.

SEC. 2.—Members shall contribute to the financial maintenance of the Association through the medium of initiation fees, annual dues, and special assessments. The amount of the annual dues and the initiation fees shall be determined by the By-Laws.

Special assessments may be charged against individual members, as determined by the By-Laws, when material submitted for publication in the annual transactions of the Association exceeds such limits as may be set in the By-Laws. If, at the end of any fiscal year, there be a deficit in the current funds of the Association, the Council may send out notices to that effect and invite Active Members to contribute the necessary amount so that no deficit be carried over from one fiscal year to another. The Association may, in any regularly convened meeting, vote a special assessment for any purpose whatever, and such special assessment shall become an obligatory charge against the classes of members affected thereby.

SEC. 3.—To meet the current expenses of the Association, there shall be available all revenue derived from annual dues, special assessments, and income from Endowment Fund, subject to the provisions of Section 4 following. Funds derived from the payment of initiation fees shall not be available for current expenses.

*SEC. 4.—All funds derived from the payment of initiation fees shall be placed in a special fund, to be invested and reinvested in legal securities, to be held intact and to be known as the Endowment Fund. The Council is responsible for the proper management of the Endowment Fund, and may divert any surplus in the current funds of the Association into this fund, but may not withdraw any of the principal of the Endowment Fund except in accordance with the provisions of Section 6 following.

*SEC. 5.—The income from the Endowment Fund shall be expended as the Council directs.

*SEC. 6.—The principal of the Endowment Fund may be withdrawn, in whole or in part, under the following conditions only: The amount of principal to be withdrawn shall have been approved by the Council; it shall have been approved by a majority of the members present and voting at a regularly convened annual meeting; it shall have been tabled for one year; it shall have been finally passed by a three-fourths vote of the members present and voting at the next regularly convened annual meeting.

SEC. 7.—In the event of the dissolution of the Association, the Endowment Fund shall be distributed among national institutions of the United States and Canada in a proportion equal to the then existing ratio between the numbers of citizens of the two nations who are members of the Association.

Article VIII—Meetings

SEC. 1.—The time, place, duration, and procedure of the annual meeting of the Association shall be determined by the Council, and the provisions of the By-Laws.

SEC. 2.—A special meeting of the Association may be called on one month's notice on the written request of fifteen members. The specific purposes of the meeting must be stated in the request and in the official call for the meeting.

SEC. 3.—The annual meeting of the Council shall be held at or near the close of the fiscal year.

Article IX—Amendments

SEC. 1.—This Constitution shall in no wise be changed except by a three-fourths vote of the members present at an annual meeting, and further provided

*Final action on these proposed amendments to be taken at the annual meeting, 1940.

that the proposed alteration or amendment shall have been moved and seconded at a previous annual meeting, and that printed copies of the suggested alteration or amendment shall have been circulated among the members, and that the members shall have been specifically advised that such alteration or amendment will be voted upon.

BY-LAWS

Article I

SEC. 1.—These By-Laws shall merely interpret the Constitution and specifically apply its principles. They shall set forth no principles not included in the Constitution.

Article II

SEC. 1.—All papers read before the Association shall become the property of the Association. Authors shall leave original copies of their manuscripts with the Editor, at the time of presentation, for publication in the official journal.

SEC. 2.—When the number of papers makes it desirable, the Council may require authors to present their papers in abstract, and may set a time limit on discussions.

SEC. 3.—Members are urged to cooperate with the Registry for Chest Tumors and all other financially supported Scientific Committees of the Association.

Article IV

SEC. 1.—Candidates for membership in this Association must be formally nominated and seconded, in an approved manner, by not less than three Active or Senior Members. Such nomination must have been in the hands of the Membership Committee for not less than four months, and the name of the candidate must have been published to the Association as a whole before final action may be taken on any new candidate for election to Active or Associate Membership. Provided the foregoing requirements have been met, and the candidates have been approved by the Membership Committee and by the Council, their names shall be presented to the Association at a regularly convened annual meeting for final action. A three-fourths vote of those present and voting shall be required to elect. Any candidate for membership in this Association who has failed of election for two successive years shall automatically cease to be a candidate and may not be renominated until after a lapse of three years.

SEC. 2.—Active membership shall be limited to one hundred. The candidate, to be eligible, must be resident in the United States or Canada, must be a graduate in medicine of not less than ten years' standing, and must have made a meritorious contribution to knowledge pertaining to the thoracic field. In unusual circumstances the ten-year requirement will be waived.

SEC. 3.—Associate Membership shall be limited to one hundred. The candidate, to be eligible, must be a native of or resident in the United States or Canada, and must be a graduate in medicine of not less sthan five years' standing. The limited period of time for Associate Membership, as required by Article IV, Sec. 2, of the Constitution, shall be five years.

SEC. 4.—The number of Senior Members shall be unlimited. The candidate, to be eligible, must have been an Active Member of this Association for not less than ten years, or, having been an Active Member, have passed the age of sixty, or become incapacitated by illness.

SEC. 5.—Honorary Members shall be limited to twenty-five. The candidate, to be eligible, may be a citizen of any country, does not necessarily have to hold a degree in medicine, but must have made an exceptional contribution to knowledge pertaining to the thoracic field.

SEC. 6.—The report of the Membership Committee shall be rendered at the annual executive session of the Association. Candidates shall be presented in groups in the following order: Candidates for Honorary Membership; retirement of Active Members to Senior Membership; Associate Members eligible to Active Membership; candidates for Active Membership; candidates for Associate Membership.

SEC. 7.—The Council shall recommend that any member whose dues are in arrears for two years, or who has been absent, without sufficient excuse, from four consecutive annual meetings, shall have his membership terminated.

Article V

SEC. 1.—The President of the Association shall perform all duties customarily pertaining to the office of President. He shall not only preside at all meetings of the Association, but also at all meetings of the Council. The President shall be elected from the Active Members of the Association.

SEC. 2.—The Vice-President of the Association shall perform all duties customarily pertaining to the office of the Vice-President, not only as to the Association, but also as to the Council. The Vice-President shall be elected from the Active Members of the Association.

SEC. 3.—The Secretary of the Association shall perform all duties customarily pertaining to the office of Secretary. He shall serve not only as Secretary of the Association but also as Secretary of the Council. The Secretary shall be elected from the Active Members of the Association.

SEC. 4.—The Treasurer of the Association shall perform all duties pertaining to the office of Treasurer. He shall not only serve as Treasurer of the Association but shall also serve as custodian of the Endowment Fund. The Treasurer shall be elected from the Active Members of the Association.

SEC. 5.—The Editor of the Association shall be the Editor of the official Journal; shall, ex officio, be the Chairman of the Editorial Board; and shall be custodian of the permanent completed archives and records of the Association. The Editor shall be elected from the Active or Senior Members of the Association.

SEC. 6.—The Councilors of the Association shall hold office as specified in the Constitution. They may be elected from either the Active Members or the Senior Members of the Association.

SEC. 7.—In the event of a vacancy occurring in the office of President, the Council shall advance the Vice-President to the Presidency and appoint a new Vice-President under the Provisions of Article V, Sec. 3, of the Constitution.

Article VI

SEC. 1.—The Nominating Committee shall consist of three Active or Senior Members elected in accordance with the provisions of Article VI, Sec. 1, of the Constitution. The Council shall instruct the Committee as to the vacancies which are to be filled by election.

SEC. 2.—The Membership Committee shall consist of five Active or Senior members appointed in accordance with the provisions of Article VI, Sec. 2, of the Constitution. The Council may appoint not more than one of its own members to serve on this Committee. The duties of the Membership Committee are to investigate all candidates for membership in the Association and to report their findings as expeditiously as possible to the Council through the Secretary of the Association. This Committee is also charged with searching the literature of this and other countries to the end that proper candidates may be presented to the Association for consideration. Appointment to this Committee shall be for a period of one year, and not more than three of the members may be reappointed to succeed themselves.

SEC. 3.—The Auditing Committee shall consist of three Active or Senior Members appointed in accordance with the provisions of Article VI, Sec. 2, of the Constitution. None of these may be selected from the officers or councilors of the Association. Their duty shall be to audit the accounts of the Association at the end of each fiscal year, and render their report to the Council of the Association through the Secretary. Appointments to this Committee shall be made for a one-year term. Not more than two members may be reappointed to succeed themselves.

SEC. 4.—The Program Committee shall consist of five members: The President of the Association, the Secretary of the Association, the Editor of the Association, and two members at large, one of whom shall be resident at or near the place of annual meeting. The duties of this Committee shall be to arrange, in conformity with instructions from the Council, the scientific program for the annual meeting.

SEC. 6.—The Editorial Board shall be appointed by the Editor, subject only to the approval of the Council. The Editor shall be, ex officio, the chairman of this board and shall be privileged to appoint and indefinitely reappoint such members of the Association, regardless of class of membership, and such non-members of the Association as in his opinion may be best calculated to meet the editorial requirements of the Association.

SEC. 7.—When Scientific or Research Committees are authorized by the Association, the Council shall appoint the Chairmen of these Committees, with power to organize their committees in any way best calculated to accomplish the desired object, subject only to the approval of the Council. Financial aid rendered to such Committees shall not exceed such annual or special appropriations as may be specifically voted for such purposes by the Association as a whole.

Article VII

SEC. 1.—Honorary Members of the Asssociation are exempt from all initiation fees, dues, and assessments.

SEC. 2.—Annual dues for Active Members shall be $12.50.

SEC. 3.—Annual dues for Associate Members shall be $5.00.

SEC. 4.—Annual dues for Senior Members shall be $3.00.

SEC. 5.—Initiation fee for those elected directly to Active Membership shall be $15.00.

SEC. 6.—Initiation fee for those elected to Associate Membership shall be $10.00. If and when an Associate Member is elected to Active Membership, he shall pay an additional $5.00 initiation fee.

SEC. 7.—In illustrating the annual transactions the Association will incur expenses not to exceed $15.00 per article. If the cost for illustrating any article exceeds the sum of $15.00 the excess shall be charged as a special assessment against the member concerned.

SEC. 8.—Income from the Endowment Fund shall be expended as the Council directs.

SEC. 9.—Associate and Active Members must subscribe to THE JOURNAL OF THORACIC SURGERY to retain their membership status.

SEC. 10.—Senior Members may retain their membership status by the payment of annual dues, but subscription to THE JOURNAL OF THORACIC SURGERY is optional.

(NOTE.—Bills for membership dues and for subscriptions to THE JOURNAL OF THORACIC SURGERY will be mailed to members by the Treasurer after the annual meeting.)

Article VIII

SEC. 1.—When the Association convenes for its annual meeting, it shall immediately go into executive session, but the business at this session shall be limited to:

1. Election of Nominating Committee.
2. Appointment of necessary committees.
3. Miscellaneous business of an urgent nature.

SEC. 2.—The annual executive session of the Association shall be held at the opening of the afternoon session of the second day of the meeting. The order of business shall be:

1. Reading of the minutes of the preceding meetings of the Association and Council.
2. Report of the Treasurer for the last fiscal year.
3. Report of the Auditing Committee.
4. Report of the Treasurer for the current year to date.
5. Report of the Necrology Committee.
6. Report of the Program Committee.
7. Action on amendments to the Constitution and By-Laws.
8. Action on recommendations emanating from the Council.
9. Unfinished Business.
10. New Business.
11. Report of the Membership Committee.
12. Election of new members.
13. Report of the Nominating Committee.
14. Election of officers.

SEC. 3.—At the annual meeting of the Council the order of business shall be:

1. Reading of minutes.
2. Treasurer's report.
3. Appointment of committees.
4. Determination of instructions to be given to Auditing, Membership, Necrology, and other committees except Program Committee.
5. Determination of details in connection with the annual meeting.
6. Appointment and instructions to the Program Committee.
7. Unfinished Business.
8. New Business.

SEC. 4.—There shall be an annual meeting of the Council.

Article X

SEC. 1.—These By-Laws shall in no wise be changed except by a two-thirds vote of the members present at the annual meeting or a properly convened meeting of the Association, and further provided that the proposed action or amendment shall have been moved and seconded by not less than three of the members in a properly convened annual or special meeting of the Association.

SEC. 2.—These By-Laws may be suspended in whole or in part for a period of not more than twelve hours by a unanimous vote of those present at any regularly convened meeting of the Association.

Notice of Meetings

The 1940 meeting of the Association will be held at Cleveland, Ohio, on June 6, 7, and 8. The meeting on June 6 will be at the Hotel Statler in conjunction with the National Tuberculosis Association. On June 7 and 8 the regular meeting of the American Association for Thoracic Surgery will be held in the Academy of Medicine. The headquarters for the meeting will be the Wade Park Manor which is near the Academy of Medicine.

All members of the Association are invited by the National Tuberculosis Association to make use of the exhibit facilities which will be available in connection with their meeting in Cleveland June 3-6. Any member wishing to take advantage of this offer should send his application for exhibit space to Dr. R. C. McKay, City Hospital, Cleveland, Ohio, before May 1.